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Contents

STANDARD ABBREVIATIONS USED
IN
WORLD JOURNAL OF APPLIED SCIENCES AND RESEARCH

Ampere	A
Angstrom	A°
Anti meridiem (before noon)	am
Centimetre	cm
Counts per minute	cpm
Crie	Ci
Degree	°
Degree of freedom	df
Death	d_x
Gram	gm
Gravity	g
Hour(s)	h or hr
Interperitoneal	ip
Intravenous	iv
Kilogram	kg
Lethal concentration-50	LC_{50}
Lethal dose-50	LD_{50}
Life expectancy	e_x
Litre	l
Meter	m
mg/100ml	mg/dl
Micro litre	ml
Micrometer	µm
Micro molar (mole/litre)	mM
Milli Ampere	mA
Milli molar	mM
Milligram	mg
Millilitre	ml
Millimetre	mm
Minute (s)	min
Molar (mole/ litre)	M*
Mole (quantity of substance)	mol
Nanometre	nm
Oral	po
Ortho	o
Para	p
Post meridiem (after noon)	pm
Quintal	q
Rad	R
Second (s)	sec
Significance	*p*
Square centimetre	cm^2
Subcutaneous	sc
Survival	l_x
Tonne	t
Volume	vol
Volume ratio	vol/vol
Watt	W
Week (s)	wk
Weight	wt
Weight per volume	wt/ vol
Weight ratio	wt/ wt
Year (s)	yr

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Assessment of microbial assortment in agricultural soil of district Aligarh, Uttar Pradesh, India

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Abstract

Enumeration of aerobic heterotrophic bacteria, actinomycetes and fungi were determined both in rhizospheric and non-rhizospheric soil samples of Aligarh by plate viable count. In general, rhizospheric soil showed relatively higher population density (CFU g^{-1} of soil) for all three major groups of aerobic heterotrophs as compared to non-rhizospheric soils. The viable count of aerobic heterotrophic bacteria in the rhizospheric soils of various crops ranged from 1.25×10^6 to 1.27×10^8, while in the non-rhizospheric soils it differed from 1.35×10^5 to 1.03×10^7 CFU g^{-1} soil. The viable count of bacteria differed with respect to plant species and site of sampling. Soil samples from leguminous crops showed relatively higher bacterial density as compared to non-leguminous crops within the same sampling sites. The rhizospheric effect (R/S ratio) in legume crops was considerably higher (5.7×10^4 to 1.58×10^5 CFU g^{-1} soil) in comparison to non-legume crops (1.2×10^3 to 2.7×10^4 CFU g^{-1}) at most of the sampling sites. A significant difference in the rhizosphere and non-rhizosphere fungal plate counts was recorded and R/S ratio ranged between 8.12 and 9.51. An estimate of morphological diversity of each group was done by random selection of 75-100 colonies from each sample. Aerobic heterotrophic bacteria were grouped into three types (i) Gram -ve short rods, (ii) Gram +ve rods and (iii) Gram +ve cocci. Similarly, actinomycetes were examined microscopically and distinguished as the member of Streptomyces*, Nocardia, Micromonospora* etc. In addition, predominant fungi identified as *Aspergillus, Penicillium, Mucor, Rhizopus, Geotrichum* and *Fusarium*. However, other fungi less frequently encountered in soil are *Alternaria, Cladosporium, Microsporum, Trichoderma,* yeast, *Mycellia sterilia* and many other unidentified fungi.

1. INTRODUCTION:

Soil microbial populations are immersed in a framework of interaction known to affect plant fitness and soil quality. The functions of soil microorganisms are central to decomposition process and nutrient cycling. Though the space occupied by living organisms is less than 5 percent of total space. Therefore, major microbial activity is confined to the 'hot-spot' *i.e.,* agreeable with accumulated organic matter, rhizosphere (Bowen and Roviara, 1999; Tilak et al., 2005). The soil microorganisms and their preparations (biofertilizer, biopesticides and biocontrol agents) and microbe-plant interaction have been known for their significance in maintenance and supply of plant nutrients as well as protecting plant health (Vessey, 2003). Diversity and community structure in the rhizosphere is however influenced by both, plant and soil type (Cavigelli and Robertston, 2000; Bakker et al., 2002). Plants play an important role in selecting and enriching the types of bacteria by the constituents of their root exudates. The interaction between bacteria may be beneficial, harmful and neutral for the plant and some time effect of a particular bacterium may vary as a consequence of soil conditions (Lynch, 1990).

Rhizospheric microorganisms mediate soil processes such as nitrogen fixation, synthesis of plant hormones, phosphate mineralization, decomposition, nutrient mobilization and mineralization. Among these processes, biological nitrogen fixation (BNF) offers an economically attractive alternative and ecologically sound means of reducing external inputs and improving internal resources. Biological nitrogen fixation is estimated to contribute 180×10^6 metric tons/year globally (Postgate, 1998), of which 80% comes from symbiotic associative systems (Graham and Vance, 2003). Among the BNF groups, the

symbiotic forms of rhizobia (eg. *Rhizobium*, *Bradyrhizobium* etc) is important both ecologically and agronomically, since it is a major source of nitrogen for legume crops.

Challenging possibilities are offered by combination of a gradual reduction of the use of pesticides and fertilizers on one hand and a greater use of the biological and genetic potential of plant and microbial species in another hand (Schippers et al., 1995). The current emphasis is therefore made on the use of renewable resources, which are free from environmental risk. In this context, the exploitation or use in the soil root interface (rhizosphere) are emphasized in agriculture represents an environment friendly alternative to further application of chemical fertilizers. The current study was therefore, planned to see the rhizospheric effect of different crops on the diversity of different microbes (Aerobic heterotrophs, Actinomycetes, Fungi, Fluorescent *Pseudomonas* and Nitrogen fixing bacteria) in Aligarh region. Organism's diversity of different microbial groups was also studied in different soil samples.

2. MATERIALS AND METHODS:

2.1. Collection of soil sample:

A composite of five replicates of both rhizospheric and non-rhizospheric (bulk soil at ≈15 cm depth) soils were studied, which were collected from different agricultural fields in the vicinity of district Aligarh, Uttar Pradesh, India, during the winter season. Each soil sample was processed separately for microbiological and physicochemical studies (Table 1).

Table 1. Collection sites in the vicinity of district Aligarh, Uttar Pradesh, India

Sites	Name of the crop field	Location of sites/ villages
A_1	Chickpea (*Cicer arietinum*)	University farm house (Qila road)
A_2	Sugarcane (*Saccharum officinarum*)	University farm house (Qila road)
B_1	Chickpea (*Cicer arietinum*)	Brijdham (Mathura road)
B_2	Green gram (*Vigna radiata*)	Brijdham (Mathura road)
B_3	Brinjal field (*Solanum melongena*)	Brijdham (Mathura road)
B_4	Chickpea (*Cicer arietinum*)	Brijdham (Mathura road)
B_5	Green gram (*Vigna radiata*)	Brijdham (Mathura road)
B_6	Wheat (*Triticum aestivum*)	Brijdham (Mathura road)
C_1	Indian mustard (*Brassica juncea*)	Haibatpur village
C_2	Clover barseem (*Trifolium alexandrinum*)	Haibatpur village
D_1	Chickpea (*Cicer arietinum*)	Javan village
D_2	Indian mustard (*Brassica juncea*)	Javan village
D_3	Wheat (*Triticum aestivum*)	Javan village
D_4	Green gram (*Vigna radiata*)	Javan village
D_5	Sugarcane (*Saccharum officinarum*)	Javan village
D_6	Black gram (*Vigna mungo*)	Javan village
E_1	Indian mustard (*Brassica juncea*)	Kasimpur village
E_2	Sugarcane (*Saccharum officinarum*)	Kasimpur village
E_3	Clover barseem (*Trifolium alexandrinum*)	Kasimpur village
F_1	Barley (*Hordeum vulgare*)	Sudiyal village
F_2	Chickpea (*Cicer arietinum*)	Sudiyal village
G_1	Wheat (*Triticum aestivum*)	Sumera village
G_2	Chickpea (*Cicer arietinum*)	Sumera village

2.2. Enumeration of rhizospheric and non-rhizospheric microbial population:

The microbiological characteristics like (i) aerobic heterotrophic bacteria (ii) Actinomycetes (iii) soil fungi (iv) fluorescent *Pseudomonas* (v) asymbiotic aerobic diazotrophic bacteria (*Azotobacter*) and other putative nitrogen fixers (PNF) were determined by cultural techniques using standard plate count technique (Cappuccino and Sherman, 1992) in the soil collected from different locations.

Soil suspension was prepared in sterile normal saline solution and appropriately diluted in sterile NSS. 0.1-1 ml of diluted suspension and spread on respective nutrient agar plates, incubated at appropriate temperature and time described in table 2.

2.3. Enumeration of *Pseudomonas:*

For isolation and detection of fluorescent *Pseudomonas,* soil sample (1 gm) suspended in King's B liquid medium for overnight and then diluted in normal saline solution and plated on King's B agar medium. The plates were incubated at 28-30^{o}C for 72

hr. Detection of fluorescent colonies by UV exposure indicated the presence of fluorescent bacteria.

Table 2. Growth conditions required for different groups of microorganisms

Group of microorganisms	Medium	Incubation temperature	Incubation period
Aerobic heterotrophs	Nutrient agar	28±2^{o}C	24 hr
Actinomycetes	Kenknight's agar	28±2^{o}C	10-14 days
Fungi	Martin's agar	28±2^{o}C	3-7 days

3. RESULTS AND DISCUSSION:

3.1. Isolation and characterization of rhizospheric microorganisms:

Qualitative assessment of specific groups of rhizobacteria, predominant actinomycetes and fungi were isolated on their respective media by repeated streaking and plating. The bacterial cells were differentiated by Gram's staining and on the basis of morphology. Actinomycetes were identified on the basis of colonial morphology and microscopic structures of mycelium and sporulation pattern. Fungi were identified on the basis of their vegetative mycelium reproductive structures, sporulation pattern and spore structures using standard methods as described by Cappuccino and Sherman (1992) and Gilman (1998). The bacterial isolates were characterized for their biochemical characteristics like hydrolysis of starch, lipid and chitin, utilization of glucose, sucrose, lactose, mannitol and citrate, production of catalase using standard methods (Cappuccino and Sherman, 1992) and specific testes as described in Bergy's manual of determinative bacteriology.

Viable plate count of aerobic heterotrophic bacteria, actinomycetes and fungi were determined both in rhizospheric and non-rhizospheric soil samples of Aligarh (Table 3). In general rhizospheric soil showed relatively higher viable count (CFU g^{-1} of soil) for all three major groups of soil microorganisms (aerobic heterotrophic bacteria, actinomycetes and fungi) as compared to non-rhizospheric soil. The viable count of aerobic heterotrophic bacteria in the rhizospheric soils of different crops ranged from 1.25 x 10^6 to 1.27 x 10^8 while in the non-rhizospheric soils it varied from 1.35 x 10^5 to 1.03 x 10^7 CFU g^{-1} soil. These viable counts of bacteria varied with respect to plants and sites of sample collection. Site A_1, B_1 and B_4 (*Cicer arietinum*), C_2 (*Trifolium alexandrinum*), D_3 (*Triticum aestivum*), D_6 (*Vigna mungo*), E_3 (*Trifolium alexandriunm*) and F_1 (*Hordeum vulgare*) showed relatively higher count as compared to other sampling sites. Similar trend of heterotrophic aerobic bacterial counts on nutrient agar was also observed in the non-rhizospheric soils. Soil samples from leguminous crops showed relatively higher bacterial density as compared to non-leguminous crops within same sites of sampling. The rhizospheric effect (R/S ratio) in legume crops was relatively higher in comparison to non-legume crops at most of the sampling sites (Table 3).

Similarly, the viable count of actinomycetes in the rhizospheric soil ranged from 4.2 x 10^4 to 1.58 x 10^5 CFU g^{-1} and in the non-rhizosphere soil, it varied from 1.2 x 10^3 to 2.7 x 10^4 CFU g^{-1}. Distribution patterns of actinomycetes were similar to that of aerobic heterotrophic bacteria. However, their frequency of occurrence in certain sites (A_1, A_2, B_1, B_2, C_2, D_2, D_3, E_1, F_2, G_1, and G_2) was relatively higher with other sampling sites irrespective of crop under cultivation. R/S ratio for actinomycetes ranged from 4.9 to 5.85 in different field location. The variation in R/S ratio in leguminous and non-leguminous crops of different sites is comparable as depicted in table 3.

The population density of soil fungi ranged from 1.6 x 10^5 to 5.8 x 10^5 CFU g^{-1} in rhizospheric soils, whereas, in the non-rhizospheric soils it ranged from 1.4 x 10^4 to 6.6 x 10^4 CFU g^{-1} (Table 3). A significant difference in the rhizosphere and non-rhizosphere fungal plate counts was recorded, whereas, R/S ratio was ranged from 8.12 to 9.51 (Table 3).

Qualitative estimation of morphological diversity of each group was done by random analysis of 75-100 colonies from each sample. Aerobic heterotrophic bacteria were grouped into three types (i) Gram -ve short rods, (ii) Gram +ve bacilli and (iii) Gram +ve cocci. Similarly actinomycetes were examined microscopically and distinguished as the member of *Streptomyces, Nocardia, Micromonospora* and other unidentified actinomycetes. On the other hand, predominant types of fungi belong to genera *Aspergillus, Penicillium, Mucor, Rhizopus, Geotrichum* and *Fusarium*. However, a variety of other fungi were less frequently encountered, included *Alternaria, Cladosporium, Microsporum, Trichoderma,* yeast, *Mycelia sterilia* and many other unidentified fungi.

3.2. Microbial characteristics of agricultural soil of Aligarh:

Soil microorganisms can be critically used for the maintenance of soil function in both natural and managed agricultural soils because of their

involvement in the key processes of soil structure formation; decomposition of organic matter, toxin removal, and cycling of elements/nutrients (VanElsas and Trevors, 1997). Soil microbes also play a key role in promoting plant growth and suppressing soil borne plant diseases (Doran et al., 1996). Microbial communities in root associated habitat respond with respect to density, composition, and activity to the abundance and great diversity of organic root exudates, eventually yielding plant species-specific microflora (Abawi and Thurston, 1992; Abawi and Widmer, 2000; Burdman et al., 2004; Buyer et al., 1999). Due in part to the scarcity of the convenient methods for exploration, our understanding of the different degrees and dynamics of microbial community variation is limited (Agrios, 2000; Buyer et al., 1999; Garbeva et al., 2004). The term microbial diversity describes the number of different types and their relative abundance in a given community in a particular habitat. In molecular ecological terms, it can be defined as the number and distribution of different sequence types present in the DNA extracted from the community in the habitat. However, the term community structure implies that information is included on the numbers of individuals of different recognizable taxa (Liesack et al., 1997). These divergent terms often used interchangeably. To study microbial diversity, both cultivations based and cultivation independent methods are used. However, both approaches have their own advantages and limitations (Janssen et al., 2002; Garbeva et al., 2004). Though culture dependent techniques are limited for studies on the composition of natural microbial communities in soil when used alone, yet they help in understanding the growth characteristics, potential ecological behaviour and function of microorganisms from soil habitats (Hoitink and Boehm, 1999; Kozdroj and van Elsas, 2001).

Table 3. Microbial assortment of selected microbial groups in agricultural soil of district Aligarh

Soil samples (Name of the crop)	Sample site	Plate count CFU g^{-1} of soil								
		Aerobic heterotrophic bacteria			Actinomycetes			Fungi		
		Rhizo-sphere ($x10^5$)	Non rhizo-sphere ($x10^4$)	R/S	Rhizo-sphere ($x10^3$)	Non rhizo-sphere ($x10^2$)	R/S	Rhizo-sphere ($x10^4$)	Non rhizo-sphere ($x10^3$)	R/S
Chickpea	A_1	1270±85.0	1030±406.8	12.33	158±5.00	270±22.91	5.85	43±2.65	43±17.58	9.0
Sugarcane	A_2	178±20.95	184±26.51	9.67	105±7.21	210±18.03	5.00	40±2.00	49±16.64	8.34
Chickpea	B_1	187±10.44	149±16.37	12.55	108±4.00	190±6.56	5.68	35±3.00	37±13.00	9.09
Greengram	B_2	107±15.72	944±45.57	11.26	100±7.00	180±6.24	5.43	51±5.29	59±12.17	8.7
Brinjal	B_3	127±12.38	115±13.23	9.055	68±9.64	130±10.58	5.1	53±1.00	66±7.00	8.12
Chickpea	B_4	980±62.45	850±65.57	11.53	58±6.08	110±12.29	5.3	16±1.73	18±7.21	8.93
Greengram	B_5	139±17.78	109±8.185	12.75	75±6.24	140±11.36	5.59	57±2.65	60±7.21	9.42
Wheat	B_6	480±46.89	430±51.57	8.96	73±5.57	140±7.00	5.19	49±3.61	63±6.00	8.24
Indian mustard	C_1	138±17.44	133±18.68	10.38	85±16.64	160±18.36	5.48	26±2.65	14±5.29	8.36
Clover	C_2	780±37.00	680±53.56	11.4	114±7.21	210±13.53	5.5	32±2.00	35±5.29	9.1
Chickpea	D_1	121±22.27	970±26.00	12.47	76±7.00	130±6.24	5.7	53±2.65	56±9.64	9.46
Indian mustard	D_2	182±20.66	196±26.46	10.77	116±7.55	230±18.36	5.05	54±2.65	66±7.00	8.2
Wheat	D_3	620±81.85	590±26.91	10.51	109±7.21	210±11.79	5.14	19±2.65	23±7.21	8.26
Greengram	D_4	119±21.79	103±24.06	11.55	83±4.37	150±5.57	5.37	24±4.36	27±6.24	9.25
Sugarcane	D_5	188±22.72	169±25.94	11.12	92±7.55	180±8.19	5.05	47±2.00	51±5.57	9.02
Black gram	D_6	680±63.84	920±24.27	7.39	42±6.24	90±6.56	4.9	41±4.58	47±4.36	8.72
Indian mustard	E_1	12.5±2.93	13.5±1.73	7.56	107±14.00	12±6.00	5.45	46±8.19	49±7.94	9.39
Sugarcane	E_2	127±22.91	106±4.36	11.98	57±10.44	90±10.44	5.23	37±3.46	42±5.57	8.81
Clover	E_3	890±36.06	730±26.00	11.22	64±4.58	120±12.29	5.39	24±4.58	28±7.94	8.57
Barley	F_1	880±18.33	105±11.36	8.38	89±6.08	170±7.94	5.27	25±5.29	29±8.89	8.62
Chickpea	F_2	147±14.93	114±13.23	12.89	108±7.21	190±14.00	5.65	27±4.58	29±5.19	9.31
Wheat	G_1	116±16.00	108±10.58	10.74	113±11.79	210±7.21	5.42	26±6.24	30±10.58	8.57
Chickpea	G_2	159±19.00	115±10.39	13.83	128±7.00	220±10.82	5.78	58±7.21	61±5.29	9.51

In the present investigation, plate viable counts of rhizospheric and non-rhizospheric soils of culturable microorganisms *i.e.*, aerobic heterotrophic bacteria, actinomycetes and fungi were examined. As expected, a significant increase in the microbial density of rhizospheric soil was observed compared

to non rhizospheric soils which could possibly be due to the nutrient rich environment and availability of nutrients from root exudates, which includes an array of low and high molecular weight compounds (Vainio and Hantula, 2000). Our observation demonstrated 10 fold increases in the rhizospheric microbial density and is in close agreement with the reports of Weller and Thomashow (1994).

The plant and location based variations in the population density of three common groups of culturable heterotrophic aerobic microorganisms was observed, which are expected due to the several factors like age of plant, nature and types of plant root exudates, and environments like, moisture condition of field soil and field amendment (Grayston et al., 1998; Dakora and Phillips, 2002). Moreover, the variation in rhizospheric effect (R/S ratio) is also evident. The R/S ratio among leguminous crops *viz.*, *Cicer arietinum*, *Vigna* spp. and *Trifolium alexandrium* varied from 11.5 to 13.8 (bacteria), 7.4 to 12.8 (actinomycetes) and 1.2 to 11.4, (fungi) respectively among these groups of microorganisms. A similar variation among non-leguminous crops was also observed suggesting that the rhizosphere effects can be different for both leguminous and non-leguminous crops.

The viable plate counts of soil actinomycetes ranged from 5.7 x 10^4 (*Saccharum officinarum*) to 1.58 x 10^5 (*Cicer arietinum*) CFU g^{-1} in the rhizosphere of different crops and 1.2 x 10^3 to 2.7 x 10^4 CFU g^{-1} which showed their abundance both in the rhizospheric and non rhizospheric soils. The R/S ratio varied from 4.9 to 5.9 which are lower than the R/S ratio of aerobic heterotrophic bacteria (7.4 to 13.8). The low R/S ratio observed in this study could probably be due to the poor competitive nature of actinomycetes as compared to other heterotrophic bacteria and fungi. Common types of actinomycetes identified include the member of *Streptomyces, Nocardia* and *Micromonospora* (Alexander, 1985; Curl and Truelove, 1986; Atlas and Bartha, 1991).

Table 4. Morphological and biochemical characteristics of the test isolates

Biochemical characters	Fluorescent *Pseudomonas* 27*	*Bacillus* species 30*	*Azotobacter* species 35*	PutativeN_2 fixers 25*
Pigmentation	diffusible fluorescent green pigment	–	Transparent, milky, some become blackish brown on aging	–
Colony Morphology	Button shaped	Serrated, irregular Margins	Watery, Mucilaginous Shrink, Serrated margins	Transparent watery, colonies, entire margins
Gram reaction	Negative	Positive	Negative	Mostly Gram negative**
Cell shape	Rods	rods	Rods	Rods
Growth on N_2 free medium	–	–	+	+
Catalase, Citrate test	100	100	100	100
Oxidase test	100	80	20	40
Hydrolysis Starch	55.56	80	68.09	40
Lipid Utilization	77.78	80	48.94	50
Glucose	55.56	10	22.2	48
Lactose	11.11	70	11.11	40
Sucrose	33.33	60	33.33	60
Mannitol	11.11	70	36.17	25

*Total number of isolates, values are in percent (%), ** One isolate is Gram +ve
Chitin and cellulose hydrolysis- Isolates of all groups were negative

A third group of microorganism, soil fungi are an important eukaryotic microorganism responsible for degradation of organic matter, nutrient cycling and number of activities including symbiotic relationship with plant root. In this study, the quantitative estimate of free living soil fungi revealed the density as 1.6 x 10^5 CFU g^{-1} to 5.8 x 10^5 CFU g^{-1} in the rhizosphere soil and 1.4 x 10^4 to 6.6 x 10^4CFU g^{-1}

in the non rhizosphere soil while, the R/S ratio ranged between 8.1 and 9.5. Plant and location based differences in the quantitative value of free living fungi are also evident like bacteria. Population density of above tropical soil microbes is in the range as found in the fertile soil (Alexander, 1985). In the rhizosphere soil member of the genera *Aspergillus, Penicillium, Rhizoctonia, Geotrichum* and *Fusarium* are found more frequently.

The above observations were based on only small fraction of cultivable heterotrophic microorganisms which were common representative groups in the plate culture method. Therefore other culturable and non culturable microorganisms including both free living, symbiotic (VAM fungi) and endophytic organisms needs to be investigated further using modified cultural media and direct DNA extraction PCR based molecular techniques, as adopted by many workers of the developed countries (Gomes et al., 2001; Kowalchuk et al., 1997; Smith and Read, 1997; Vainio and Hantula, 2000; Khan, 2006). Many authors are of the opinion that both cultivation based and culture independent molecular approaches (polyphasic) are most appropriate way of assessing microbial diversity in any given habitat (Hill et al., 2000; Kozdroj and Van Elas, 2001).

Major morphological groups of soil bacteria enumerated could be distinguished as Gram +ve rods (mainly *Bacillus*), Gram -ve short rods and Gram +ve cocci. The quantitative analysis of the rhizosphere indicated a relatively higher number for Gram –ve rods followed by Gram +ve rods and least Gram +ve cocci (Table 4).

Fluorescent *Pseudomonas* and asymbiotic N_2 fixers are commonly associated with rhizospheric soil with varying frequencies. Our findings are in agreement with the reports of many workers (Alexander, 1985; Paul and Clark, 1996).

The variation in the frequency of occurrence of *Bacillus*, fluorescent *Pseudomonas*, *Azotobacter* and putative nitrogen fixing bacteria in rhizospheric soil is probably due to the influence of a number of factors including environmental factors, plant and soil type and soil management. It seems that plant type is an important factor determining the structure of microbial communities in soil, as the exudates released from the root system of plants provide the specific carbon (5-21%) and energy source required for microbial growth (Marschner, 1995; Germida et al., 1998; Grayston et al., 1998; Vainio and Hantula, 2000; Kaiser et al., 2001).

However, influence of various factors on microbial density/ diversity could be more precisely studied by molecular/ PCR based methods as used by many laboratories where facility exists (VonWintzingerode et al., 1997; Janssen et al., 2002; Garbeva et al., 2004; Chaobat et al., 1996; Antoun et al., 1998). Due to lack of facility, we could not make an attempt to assess the genetic diversity of rhizobacteria.

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Evaluation of the genotoxic potential of Lambda-cyhalothrin in cultured lymphocytes of *Rattus norvegicus* (Berkenhout)

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Abstract

The rise of human population has crossed all strides in the beginning of 20th century with the result scientists had to employ all tactics to feed the rising population. During this course some of the synthesized chemicals not only helped the mankind but at the same time became reasons for his agony. λ-cyhalothrin being a third generation pesticide contains α-cyno group and is available in a number of formulations selected for present study to evaluate its effect on genotoxiology. Genotoxic potential of λ-cyhalothrin (LCT) was evaluated *in vivo* in the cultured albino rat lymphocytes on the basis of chromosomal aberration (CA) assay. The LCT was administered to albino rats as repeated oral doses of 18 mg/kg body weight to acute group; 0.6 mg/kg body weight to sub acute group up to 30 days, while recovery group did not receive any dose after 30 days till day 45. The negative control received the vehicle (ground nut oil) only. Mitomycin C (MMC) was used as a positive control (1.5 mg/kg body weight), administered intraperitoneally. Significant clastogenic potential has been observed after 30 days sub acute treatment. The types of chromosomal aberrations observed in present study include chromosome gap, chromosome break, chromatid gap, chromatid break and fragments. LCT possesses potential to induce cytogenetic changes in lymphocytes, which are mostly used in defense and cell immunity. These changes inform of chromosomal aberrations are indicative of possibility of the experimental compound to exerts stress at such a higher level of food chain. The pyrethroids may be problematic like conventional pesticides of yester years.

1. INTRODUCTION:

The population of the world is increasing continuously since time immemorial and utilization of natural resources is on increase. The rise of human population has crossed all strides in the beginning of 20th century with the result scientists had to employ all tactics to feed the rising population. It became essential to look for newer avenues to minimize the misery and plight of human population. In this situation few chemicals were synthesized which were identical to natural origins. The pyrethroids were such in this series. To overcome the problem of food requirement, biologically safe pyrethroids are in vogue. However, their indiscriminate use is not free of problems. Unfortunately pesticides have diverse effects on the specific target species. Undesirable side effects are wide spread and include injury to non-target organisms, ecosystem imbalance and environmental contamination by persistent pesticides. Pesticides are biological, physical and chemical agents used to kill organisms, which are harmful to human beings. Pesticides might be incorporated into plant tissue and food grains and as a result of this they enter into food chain and accumulated at various tropic levels after each generation through biomagnification. Such pesticides are a menace, in a sense that they get entry into the mammalian body and cause alterations in various cytological, biochemical and physiological processes leading to serious complications.

The genotoxic effects of λ-cyhalothrin (LCT) were investigated in various animal species using chromosomal aberration (CA), micronucleus formation (MN) and banding pattern analysis (Agrawal et al., 1994; Campana et al., 1999; Fahmy and Abdalla, 2001; Celik et al., 2003; Sharma, 2004). The bone marrow is most widely used for short-term *in vivo* assay for genotoxic study (Schmidt, 1973; Heddle 1973), however, in the present study lymphocytes have been used as they are functional in defense mechanism and can easily be obtained from

blood of the experimental animal. Although cytotoxic nature of synthetic pyrethroids is a known fact (Pati and Bhunya, 1989; Bhunya and Pati, 1990; Hayashi et al., 1994; Dianovsky and Sivikova, 1995; Nakano et al., 1996; Chauhan et al., 1997; Pandey, 2001; Singh and Saxena, 2002; Sharma, 2004), yet LCT is hereby checked for possessing the cytotoxic potential through chromosomal aberrations analysis. Earlier reports emphasize mainly bone marrow (Celik et al., 2003) for evaluating LCT toxicity however the present studies assess genotoxic potential of LCT in lymphocyte *in vivo*.

2. MATERIALS AND METHODS:

2.1. Test Compound:

For the present study λ–cyhalothrin (LCT), a non-systemic pyrethroid insecticide with the trade name 'Karate' (CAS no. 91465-08-06), chemical name (R+S)-F-cyano-3 methyl-(phenoxyphenyl)-(1S+1R)-cis-3-(2-2chloro-3,3,3-trifluoroprop-1-enyl)-2-2-dimethyl -cyclopropane-carboxylate of 98 % purity, with contact and stomach action and repellent properties was procured from Zeneca-ICI Agro Chemicals, Chennai, India.

2.2. Maintenance of Experimental Albino Rats:

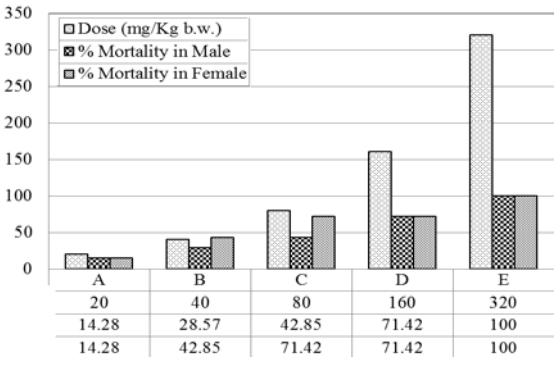
The experimental albino rats (*Rattus norvegicus,* Berkenhout), procured from inbred colony were acclimated for one month to the laboratory conditions (temperature. 25±0.5°C, relative humidity 60±5% and photoperiod 12 hr/day) before using them for the experiment. Adult male and female rats of almost equal size and weight were kept in the polypropylene cages and cleaned regularly to avoid any infection or undesirable odour in the laboratory. Each cage was equipped with a metallic food plate and water bottle. The albino rats were offered fresh feed daily throughout the experimentation on Gold Mohar rat and mice feed, manufactured by Hindustan Lever Ltd., India at regular interval and water was provided *ad libitum.*

2.3. Random Selection of Individuals:

In the present study, for LD_{50} the data were analyzed statistically by log dose/probit regression line method (Finney, 1971). Oral LD_{50} of male and female rats was found to be 75.85 mg/kg body weight and 56.695 mg/kg body weight, respectively (Saxena and Sharma, 2002; Sharma, 2004). The percent mortality response in the two sexes as per figure1, did not reveal any significant change ($p>0.05$). Hence, it could be possible to select the individuals randomly (irrespective of sex) for experimentation.

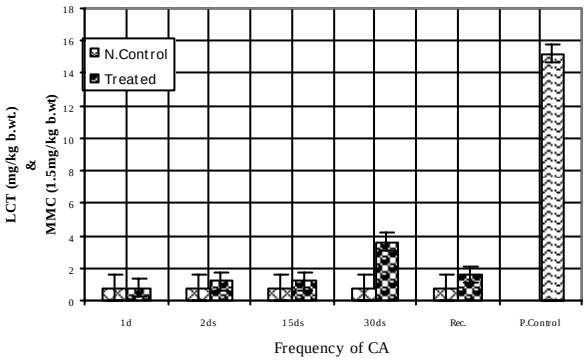
Five healthy adult albino rats (7-8 weeks of age, with average body weight of 150-200 g) were selected randomly for test, control and recovery studies sacrificed after 1, 2, 15, 30 and 45 (recovery) days for the collection of blood. Each rat was assigned a number for convenience prior to experimentation. All the rats of the experimental sets were given doses of LCT orally with the help of gavage tube and those of control sets equal amount of vehicle *i.e.* ground nut oil.

Fig. 1. Percent mortality of λ-cyhalothrin in male and female albino rats, *R. norvegicus* after oral dosing



	A	B	C	D	E
Dose (mg/Kg b.w.)	20	40	80	160	320
% Mortality in Male	14.28	28.57	42.85	71.42	100
% Mortality in Female	14.28	42.85	71.42	71.42	100

Fig. 2. Frequency of chromosomal aberration (%) in relation to λ-cyhalothrin in albino rat, *R. norvegicus* using cultured lymphocyte



2.4. Selection of Dose:

2.4.1. Test agent: An oral dose of 18 mg/kg body weight for acute treatment, while for sub acute treatment 1/30 of acute dose was given for 30 days *i.e.* 0.6 mg/kg body weight/day by gavage tube. The recovery group did not receive any dose after 30 days of sub acute treatment till day 45.

2.4.2. Positive control: Mitomycin C (MMC), CAS no. 50-07-7 was used as a positive control. MMC was given as a single dose of 1.5 mg/kg bwt via intraperitoneal injection. It is acceptable that a positive control is administered by a route different from or the same as the test agent and that it is given only a single time (Hayashi et al., 1994).

2.4.3. Negative control: Negative controls consisting of vehicle (groundnut oil) were treated with all treatment groups.

2.5. Collection of Blood Samples:

In the early morning hours (7-8 am) on the due date of autopsy the rats were warmed under the desk lamp to facilitate bleeding. Enough care was taken to avoid them going into heat shock. Over heated condition was depicted by beads of perspiration on the nose or excessive activity. The rats were placed in a restraining block and swabbed the tail first with 70% ethanol, then with 90% ethanol. After the alcohol was evaporated, a small slit was made in the underside of the tail about 1 inch from the base of the tail by a flamed razor blade. First two drops of blood were discarded to avoid contamination; Blood collecting tubes were gently flamed just before and just after the blood was collected. After collection 8-10 drops of blood, the tube was agitated gently to mix the blood and heparin solution. The blood collecting tubes were tightly capped and stored at 37°C.

2.6. Chromosomal Aberration Assay:

Chromosomal aberration was performed in cultured lymphocyte according to the methodology proposed by Triman et al. (1975) with slight modifications.

2.6.1. Inoculation of culture: For culture 0.1 ml of the blood-heparin mixture was added to each prepared culture vials containing 0.1 ml phytohemagglutinin (PHA) and 0.8 ml supplemented medium (containing RPMI 1640, 25 mM Hepes buffer, fetal calf serum and penicillin-streptomycin solution), to bring the final culture volume to 1.0 ml. The cultures were mixed well and capped tightly. The cultures were incubated at an angle of approximately 5° from horizontal at 37°C for 24 hours.

2.6.2. Culture growth in media: The cultures were centrifuged after 24 hours at 200 x g for 8 min. The supernatant was removed and discarded aseptically with a sterile Pasteur pipette. The medium was replaced with 0.8 ml of supplemented medium and 0.1 ml of PHA. The culture was mixed gently; bubbling was avoided, with a sterile Pasteur pipette, and returned to the 37°C incubator for another 24 hours. 5 µg of colchicine was added to each culture at 48 hours and mixed gently and thoroughly with a Pasteur pipette. It was incubated at 37°C for an additional 4 hours.

2.6.3. Harvesting and hypotonic treatment of cells: Each culture was transferred to a 15 ml conical centrifuge tube and centrifuged at 200 x g for 8 min at 52 hours. The supernatant was removed carefully with a Pasteur pipette. 1.0 ml of 0.075 m KCl was added slowly to the cells without disturbing the pellet. The culture was mixed gently with a Pasteur pipette and bubbling was avoided. The cultures were returned to the 37°C incubator for 10 min, centrifuged them at 1200 rpm for 10 min.

2.6.4. Fixation: The supernatant was carefully removed with a Pasteur pipette leaving a volume approximately 0.25 ml including the cell pellet. Chilled fixative (glacial acetic acid: methonal, 1:3) was added very slowly down the inside of tube to avoid clumping of the lysed cells. When the total volume of the culture and fixative become 1.0 ml, mixed it gently by rapid pipetting. 1.0 ml of fixative was then added to bring the volume to 2.0 ml and mixed the culture again. At this point the culture was tightly capped and refrigerated overnight.

2.6.5. Slide preparation and staining: Before slide preparation culture was centrifuged at 1200 rpm for 5 minutes, removed the supernatants fixative (leaving the volume of 0.5 ml), and added 1.5 ml of fresh fixative. This washing procedure was repeated two more times before using this for slide preparation. Two drops of above suspension were dropped on to a clean, chilled, wet slide. The sides and back of slide were quickly blotted and simultaneously blew once across slide and placed onto slide warmer to dry. Slides were immediately coded with a random number, which had been correlated with the animal number. The dried slides were stained in 4% Giemsa (in phosphate buffer pH 6.8). Slides were dried thoroughly, and cover slips were applied.

2.6.6. Metaphase scoring: Hundred well spread intact metaphases were scored through blind scoring from each animal number under 100 x oil immersion. The abnormalities suggested by the "Ad Hoc Committee of Environmental Mutagen Society and The Institute for Medical Research" (1972) were considered which included chromatid and chromosome breaks, fragments of untraceable origin. Chromatid and chromosome gaps were recorded but were not included as aberrant features in the final evaluation (Myles et al., 1978). The values were calculated by using following formula (Singh and Saxena, 2002).

2.6.7. Frequency of aberrant cells:

$$\text{Frequency of aberrant cells} = \frac{\text{Total aberrant cells}}{\text{Total No. of cells studied}}$$

2.6.8. Percentage of aberrations:

$$\text{Percentage of aberrations} = \frac{\text{Total aberration (excluding gaps)}}{\text{Total No. of cells studied}} \times 100$$

2.7 Statistical Analysis:

The data collected are compared by 't' test and expressed as mean±SE.

3. RESULTS:

The metaphase analysis of the lymphocytes revealed various types of chromosomal aberrations, which consisted of chromatid, chromosome gaps and breaks, and fragments. Relatively higher frequencies of gaps and fragments were observed for all the doses tested (Table 1). A quantitative assessment of the distribution of breaks and gaps revealed that the distal regions of the long chromosomes were more vulnerable to the effects of LCT. The frequency of CA is increased with increasing concentrations of LCT (Fig. 2), and statistically non-significant ($P > 0.05$). Differences from the negative control were observed, except at the 30 days sub acute treatment ($P < 0.05$). The mean of the induced CA were range from 0.8±0.55 to 3.6±0.55 in different treatment groups, while in recovery groups it was 1.6±0.84 on comparison to controls. Such values were much lower than those induced by the positive control Mitomycin C (1.5 mg/kg bwt) (15.2±1.2).

Table 1. Chromosomal aberration analysis in peripheral blood lymphocytes of albino rat, *R. norvegicus*

S. No.	Treatment	Dose (mg/kg b. w.)	No. of individuals treated	Treatment time (In days)	No. of Cells / animal	Chromosomal aberration					Total		% of aberration without gap		Frequency of aberrant cell	
						Gap		Break								
						Chromatid	Chromosome	Chromatid	Chromosome	Fragments	Without Gap	With Gap	Mean± S.E.	Significance	Mean± S.E.	Significance
1.	Negative Control		5	01	250/5	1	-	1	-	1	2	3	0.8±0.55		0.004±0.004	
2.	Acute	18	5	01	250/5	2	-	1	-	1	2	4	0.8±0.55	p>0.05	0.016±0.008	p>0.05
3.	Negative Control		5	02	250/5	1	-	1	-	1	2	3	0.8±0.55		0.004±0.004	
4.	Acute	18	5	02	250/5	1	-	1	-	2	3	4	1.2±0.55	p>0.05	0.004±0.004	p>0.05
5.	Negative Control		5	15	250/5	1	1	-	1	1	2	4	0.8±0.55		0.008±0.005	
6.	Sub-acute	0.6	5	15	250/5	2	1	1	1	1	3	6	1.2±0.55	p>0.05	0.012±0.009	p>0.05
7.	Negative Control		5	30	250/5	1	-	1	-	1	2	3	0.8±0.55		0.008±0.005	
8.	Sub-acute	0.6	5	30	250/5	1	1	2	3	4	9	11	3.5±0.55	p<0.05	0.036±0.008	p<0.02
9.	Negative Control		5	45	250/5	2	-	-	1	1	2	4	0.8±0.55		0.008±0.005	
10.	Recovery	0.0	5	45	250/5	1	1	1	1	2	4	5	1.6±0.84	p>0.05	0.008±0.005	p>0.05
11.	Positive Control	1.5	5	2	250/5	13	11	15	12	11	38	62	15.2±1.2	p<0.001	0.120±0.050	p<0.01

4. DISCUSSION:

In the present investigation, non-significant induction of clastogenic activity of 3-cyhalothrin has been observed in acute, sub acute (15ds) treatment, and recovery groups, while in 30ds sub acute treatment clastogenic potential has been observed. Similarly workers of USEPA (1989) and WHO (1990) working group failed to observe clastogenic potential under LCT stress, while Campana et al. (1999), Fahmy and Abdalla (2001) and Celik et al. (2003) demonstrated clastogenic potential of λ-cyhalothrin in fish, mouse and wistar rat in red blood cells and bone marrow, respectively. The findings in the present studies are in accordance to previous reports on the clastogenic potential of synthetic pyrethroids as manifested in rodent bone marrow (Amer et al., 1993; Hrelia et al., 1994; Dianovsky and Sivikova, 1995; Nakano et al., 1996; Oraby, 1997; Singh and Saxena, 2002; Celik et al., 2003) in human peripheral lymphocyte cultures (Surralles et al., 1990; Dolara et al., 1992; Barrueco et al., 1994; Dianovsky and Sivikova, 1995), in CHO cells (Caballo et al., 1992; Barrueco et al., 1992) and in aquatic organisms (Campana et al., 1999; Caves and Ergene-Gozukara, 2003).

The effect of LCT seems to be time of exposure and concentration dependent. In 30ds sub acute treatment a significant difference in aberration has been observed, might be due to the longer duration of treatment. Hence, LCT has greater potential for inducing chromosomal aberration in long duration treatments, while its effect has been found to be non-significant in short term treatment

(Bhunya, and Pati, 1990; Ghosh et al., 1992; Carfagna et al., 1996; Celik et al., 2003). In addition, chemicals that cause damage to lysosomes and membranes of cellular system, induce the release of lysosomal or other DNAase into the cytoplasm of damaged cell and induce DNA double strand break and in those cells that survive sub lethal damage, such double strand breaks could have a variety of genotoxic effects such as mutation, chromosome aberration (Sharma, 2004).

The clastogenic property of LCT may be due to its ability to cause degenerative and necrotic damage to mammalian tissue like other pesticides (Rahman et al., 2000; Kokuritsu et al., 2003), which may probably induce lysosomal damage and release of hydrolytic enzymes. Release of hydrolytic enzymes as a result of lysosomal damage following cybil intoxication has been observed (Singh and Saxena, 2001; Saxena and Doneriya, 2004). Further, cypermethrin has been seen causing major degenerative changes in rat bone marrow cells (Pandey, 2001; Singh & Saxena, 2002).

The frequency of chromosomal aberrations was directly related to the concentration used and duration after exposure to fenvalerate in Swiss albino mice (Carfagna et al., 1996), while cytolethality was time; concentration and cell number dependent in rats is already a known fact. Further, Chauhan et al., (1997) observed greater potential of cypermethrin and deltamethrin as genotoxic agent in mice. It is thus evident that different kinds of mechanism are responsible for toxicity and clastogenicity on one side and DNA breakage and gene mutation on the other side (Sharma, 2004).

The non-significant increase in recovery group is also supported by Amer and Aboul-Ela (1985), who found that frequency of chromosomal aberration returning to normal levels of control after 14ds recovery following cypermethrin toxicity in mice, while Amer et al. (1993) revealed percentage of chromosomal aberration to be decreased as time lapses after treatment. Similarly, Sharma et al. (1988) observed that elevation in the frequency was steep up to 10^{th} day, but it was slowed down with an increase in dose and time after 2, 4-DB acid toxicity in mice. Similar mechanism may also be responsible for non-significant increase of chromosomal aberration in recovery group.

The selected cyno group derivative (λ-cyhalothrin, type-II pyrethroid) has a potential to induce genotoxic alterations in peripheral blood leucocytes particularly lymphocytes which forces its regulated application in the ecosystem else the chemical may prove its worth as a future mutagen like the conventional II^{nd} and III^{rd} generation pesticides of yester years.

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Morphometrical variation and suspected gregariousness in *Oedaleus abruptus* Thunberg (Orthoptera: Acrididae) under laboratory conditions

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Abstract

The present study deals with the morphometric variation in adult *Oedaleus abruptus* under eight experimental set-ups including different temperature (37°and 27°C) and food (*Zea mays* and *Cynodon dactylon*). The findings revealed a significant impact of different experimental conditions on the gregariousness of *Oedaleus abruptus*. Sixteen body parts were selected for morphometrical analysis and these measurements used in different body ratios and statistically analysed to know the extent of gregariousness.

1. INTRODUCTION:

Morphometrics are the measurements of morphological changes, during the life of an insect. Uvarov (1921) proposed the phase theory for *Locusta migratoria migratoria* (L), in which he distinguished phase gregaria from phase solitaria by using certain morphometrical indices. Zolotarevsky (1929) in his work on *Locusta migratoria capito* used the same measurements earlier used by Uvarov but reversed the ratios. Subsequently, Maxwell–Darling (1934) in his work on *Schistocerca gregaria* introduced few more ratios for phase determination. Finally there are a number of ratios which are internationally accepted for phase determination in locusts and their allied groups. In the present study, apart from using internationally accepted ratios, few new ratios are introduced to find out the hidden locust phase in this acridid species.

Morphometrical studies on acridids are generally confined to locusts and their related groups, which are migratory in habit. Generally, there are ten species of grasshoppers, which have shown permanent innate characteristics of being a locust, shows polymorphism and are migratory in nature but there are some non-migratory acridoids, which occasionally show polymorphism when they get conducive environment. Most of the morphological differences between polymorphic adults are quantitative and can best be appreciated by the application of exact measurements and statistical analysis. There are certain ecological factors for a solitary grasshopper, which force them to become locust. Therefore, the morphometrics of *Oedaleus abruptus* were carried out on certain body parts to obtain the rate of increase.

Oedaleus abruptus belongs to the sub family Oedipodinae of family Acrididae. It is a devastating pest of graminaceous crops in north India. It is widely distributed in Pakistan, Bangladesh, Afghanistan, Sri Lanka, Thailand, Malaysia etc. This pest inflicts damage to Maize *(zea mays*), Sorghum *(Sorghum vulgare*), Pearl millet *(Pennisetum typhoideum*), Wheat (*Triticum aestivum*), Sugarcane *(Saccharum offcinarum*), Paddy (*Oryza sativa*) and while attacking these crops showing a peculiar behaviour of band formation (Khan and Ali, 2012).

The objective of the present work was to study the impact of different environmental factors on the morphometrics of *Oedaleus abruptus* in the different experimental set-ups to quantify the hidden locust behaviour as in the locusts.

2. MATERIALS AND METHODS:

2.1. Collection Sites and Habitat:

The nymphs and adult of *Oedaleus abruptus* were collected from suburban area of district Aligarh *viz.*, Scindhia fort, Patwari ka nagla, Panethi, Kwarsi, Ausafpur, Kidhara, Bairamgari and Talaspur. The collection sites are located in the western part of Uttar Pradesh, India at a distance of about 126 km from New Delhi, the capital of country. It spreads

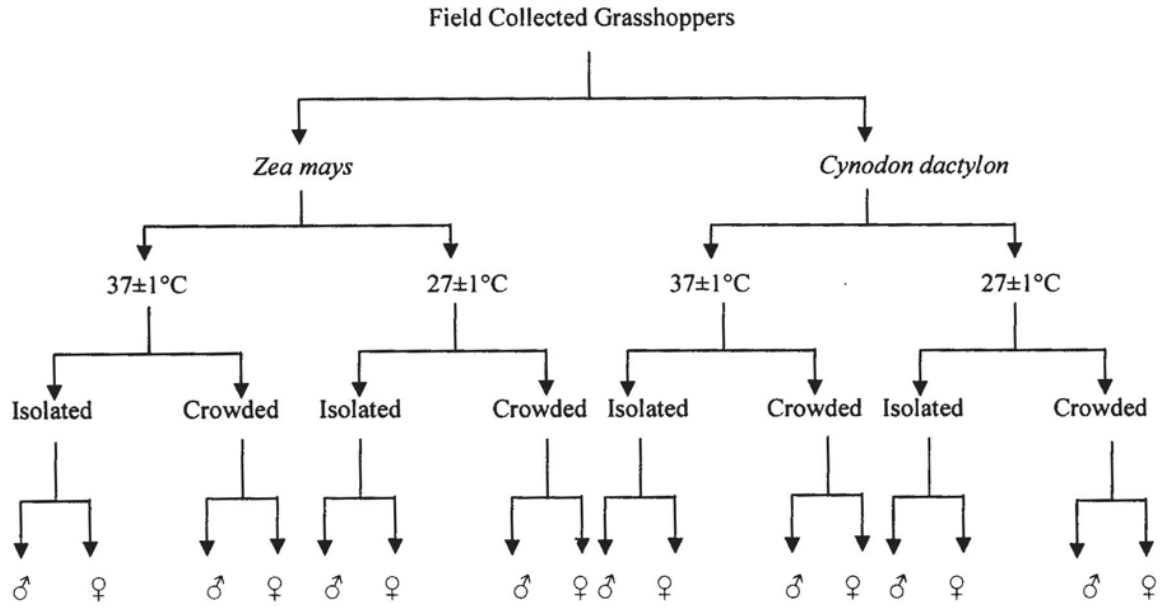
from 27º29' to 28º10' North latitude and 77º 29' to 78º 38' East longitude. The greatest width from west to east is about 116 km and the maximum length from north to south is about 72 km.

2.2. Rearing of *Oedaleus abruptus*:

Mature and immature stages of *Oedaleus abruptus* were collected from the fields of different graminaceous crops *viz.*, Maize, Sorghum, Barley, Wheat, Sugarcane and pastures predominantly in the monsoon season by sweeping net and brought to the laboratory for rearing in specially designed wooden cages (53 × 40 × 30 cm). Three sides of the cage were made up of wood with glass panel on the front. The central portion of floor of cages provided with wire mesh for proper ventilation while sides of the floor made up of wood. One side of floor of cages were provided with holes (diameter 4.00 cm) for metallic egg laying tubes of 4.0 x 10.5 cm in size, filled with sterilized sand for egg laying. An electric bulb was also fitted in one corner on the roof to regulate the temperature and photoperiod as needed by changing the wattage of bulb.

Each cage was provided with a few dry wood sticks for perching, moulting, basking of grasshoppers and also for supporting the leaves supplied as diet (*Zea mays* and *Cynodon dactylon*). The field-collected grasshoppers were separated into two groups; one fed on *Z. mays* while other on *C. dactylon* and reared in wooden cages in thermo regulated insectary at 37°C and 27°C (Fig. 1). The egg laying tubes from both wooden cages were kept separately in glass jars (15 x 20), covered with muslin cloth and incubated at 27±1°C and 37±1°C and relative humidity of 70± 5 %.

Fig. 1. Experiment plan



The egg pods were moistened daily according to their requirement. After definite incubation period the newly hatched grasshoppers were transferred to other glass jars (15 x 20 cm) by using aspirator and again separated in two groups. One kept in isolated condition and other in crowded condition. When the hoppers attained the adult stage they were transferred to the cages. In isolated condition, a single individual was reared and in crowded condition, 50 individuals were kept together in the same size of jars. Mortality in the main experimental setup may affect the results, therefore, three set of parallel experiments were run to maintain the number of grasshoppers in the main experimental setup (Khan and Ali, 2012). Further to testify the extent of impact of different experimental conditions on the gregariousness of *O. abruptus*, morphometrics of different body parts were done as per suggestions of Albrecht (1953).

2.3. Morphometrics:

Linear measurements of various body parts of male and female *O. abruptus* were made separately with the help of Dial Vernier calliper. For denoting the different parts of the body of grasshoppers the terminology used by Albrecht (1953) was adopted. All measurements were made on 30 males and 30 females for each condition. The ratio of different body parts of *O. abruptus* were taken to ascertain their gregariousness.

3. RESULTS AND DISCUSSION:

Grasshoppers change body colour, dimension, physiology and behaviour in response to different environmental condition as in the present experimental setup. The morphometrics of their body parts can be quantify in better way. The results of measurements of different body parts revealed an impact of different experimental set-ups and showed corroboration with the overview of Cisneiros *et al.*, 2012).

Table 1. Means, Standard errors and Standard deviations of crowded and isolated adults of *O. abruptus* at 37±1°C fed on two different foods

Symbols	Males				Females			
	Crowded/ *Zea mays*	Isolated/ *Zea mays*	Crowded / *C. dactylon*	Isolated/ *C. dactylon*	Crowded / *Zea mays*	Isolated/ *Zea mays*	Crowded/ *C. dactylon*	Isolated/ *C. dactylon*
B	1.44±0.020 (0.065)	1.42±0.020 (0.065)	1.59±0.046 (0.146)	1.61±0.016 (0.076)	1.96±0.026 (0.084)	1.92±0.019 (0.073)	1.88±0.042 (0.135)	1.90±0.049 (0.157)
C	0.27±0.005 (0.017)	0.23±0.003 (0.009)	0.27±0.003 (0.009)	0.28±0.006 (0.019)	0.33±0.005 (0.017)	0.26±0.004 (0.013)	0.32±0.006 (0.021)	0.32±0.007 (0.024)
M	0.24±0.005 (0.016)	0.23±0.004 (0.012)	0.24±0.005 (0.018)	0.23±0.006 (0.021)	0.30±0.005 (0.016)	0.21±0.003 (0.015)	0.28±0.002 (0.009)	0.29±0.005 (0.018)
Mx	0.28±0.006 (0.019)	0.26±0.003 (0.011)	0.25±0.002 (0.008)	0.26±0.005 (0.015)	0.34±0.03 (0.012)	0.23±0.003 (0.015)	0.31±0.004 (0.015)	0.33±0.005 (0.018)
P	0.35±0.003 (0.011)	0.35±0.004 (0.013)	0.33±0.008 (0.026)	0.24±0.008 (0.026)	0.43±0.005 (0.016)	0.31±0.003 (0.013)	0.40±0.010 (0.032)	0.41±0.005 (0.018)
H	0.30±0.002 (0.009)	0.32±0.003 (0.011)	0.32±0.006 (0.019)	0.30±0.006 (0.020)	0.34±0.003 (0.012)	0.28±0.002 (0.009)	0.33±0.004 (0.013)	0.33±0.004 (0.013)
V	0.11±0.002 (0.008)	0.11±0.003 (0.010)	0.11±0.002 (0.009)	0.11±0.003 (0.011)	0.13±0.002 (0.007)	0.12±0.003 (0.008)	0.12±0.001 (0.004)	0.12±0.002 (0.009)
D	0.10±0.002 (0.009)	0.10±0.003 (0.010)	0.09±0.002 (0.008)	0.10±0.003 (0.010)	0.13±0.006 (0.006)	0.10±0.002 (0.006)	0.11±0.002 (0.007)	0.11±0.002 (0.007)
AF	0.31±0.004 (0.013)	0.29±0.003 (0.012)	0.28±0.006 (0.019)	0.30±0.010 (0.033)	0.33±0.006 (0.021)	0.25±0.004 (0.015)	0.31±0.009 (0.028)	0.33±0.004 (0.014)
MF	0.34±0.003 (0.011)	0.32±0.002 (0.007)	0.32±0.005 (0.018)	0.33±0.007 (0.024)	0.36±0.004 (0.015)	0.28±0.003 (0.013)	0.37±0.005 (0.016)	0.37±0.005 (0.015)
F	0.95±0.016 (0.053)	0.89±0.005 (0.016)	0.89±0.014 (0.047)	0.92±0.018 (0.059)	1.02±0.013 (0.041)	0.74±0.007 (0.029)	0.99±0.010 (0.033)	1.01±0.014 (0.044)
Ti	0.85±0.015 (0.049)	0.78±0.018 (0.059)	0.68±0.018 (0.060)	0.82±0.020 (0.066)	0.92±0.014 (0.046)	0.65±0.007 (0.051)	0.77±0.016 (0.051)	0.83±0.026 (0.082)
E	1.83±0.024 (0.078)	1.83±0.023 (0.075)	1.80±0.047 (0.150)	1.87±0.028 (0.090)	1.72±0.039 (0.124)	0.45±0.009 (0.055)	1.75±0.027 (0.087)	1.74±0.044 (0.140)
O	0.16±0.003 (0.009)	0.15±0.001 (0.005)	0.16±0.003 (0.009)	0.16±0.003 (0.009)	0.18±0.004 (0.012)	0.16±0.002 (0.008)	0.15±0.004 (0.013)	0.16±0.005 (0.017)
Oh	0.11±0.002 (0.006)	0.11±0.002 (0.006)	0.12±0.002 (0.008)	0.12±0.002 (0.009)	0.13±0.003 (0.012)	0.11±0.002 (0.006)	0.11±0.001 (0.004)	0.12±0.003 (0.009)
A	0.81±0.007 (0.025)	0.82±0.008 (0.026)	0.81±0.006 (0.021)	0.81±0.006 (0.021)	0.74±0.007 (0.023)	0.45±0.004 (0.017)	0.72±0.007 (0.007)	0.72±0.008 (0.025)

B = Length of body
C = Max. width of head
M = Min. width of pronotum
Mx = Max. width of pronotum
P = Length of pronotum
H = Height of pronotum
V = Width vertex between eyes
D = Perpendicular distance
AF = Length of anterior femur
MF = Length of middle femur
F = Length of posterior femur
Ti = Length of posterior tibia
E = Length of elytron
O = Vertical diameter of eye
Oh = Horizontal diameter of eye
A = Length of antenna

Table 2. Means, Standard errors and Standard deviations of crowded and isolated adults of *O. abruptus* at 27±1°C fed on two different foods

Symbols	Males				Females			
	Crowded/ *Zea mays*	Isolated/ *Zea mays*	Crowded / *C. dactylon*	Isolated/ *C. dactylon*	Crowded / *Zea mays*	Isolated/ *Zea mays*	Crowded/ *C. dactylon*	Isolated/ *C. dactylon*
B	1.57±0.024 (0.078)	1.48±0.030 (0.096)	1.59±0.024 (0.077)	1.62±0.029 (0.094)	1.87±0.020 (0.064)	1.82±0.047 (0.150)	1.82±0.025 (0.080)	1.76±0.020 (0.065)
C	0.24±0.002 (0.008)	0.25±0.005 (0.015)	0.26±0.007 (0.023)	0.26±0.003 (0.009)	0.29±0.008 (0.026)	0.27±0.008 (0.027)	0.29±0.008 (0.028)	0.31±0.005 (0.018)
M	0.22±0.004 (0.015)	0.21±0.006 (0.021)	0.24±0.008 (0.027)	0.22±0.004 (0.014)	0.25±0.005 (0.017)	0.25±0.010 (0.034)	0.23±0.003 (0.010)	0.26±0.005 (0.018)
Mx	0.24±0.004 (0.014)	0.24±0.004 (0.014)	0.23±0.006 (0.019)	0.24±0.005 (0.018)	0.26±0.007 (0.022)	0.25±0.007 (0.022)	0.25±0.008 (0.026)	0.28±0.005 (0.018)
P	0.31±0.007 (0.022)	0.30±0.006 (0.021)	0.31±0.04 (0.014)	0.32±0.009 (0.029)	0.37±0.008 (0.025)	0.37±0.009 (0.030)	0.36±0.005 (0.017)	0.37±0.008 (0.028)
H	0.30±0.005 (0.015)	0.30±0.004 (0.014)	0.29±0.010 (0.033)	0.28±0.008 (0.025)	0.28±0.013 (0.043)	0.29±0.006 (0.020)	0.30±0.013 (0.042)	0.32±0.006 (0.020)
V	0.11±0.003 (0.012)	0.09±0.002 (0.006)	0.10±0.002 (0.007)	0.12±0.005 (0.017)	0.12±0.002 (0.007)	0.11±0.002 (0.006)	0.11±0.004 (0.013)	0.12±0.004 (0.012)
D	0.09±0.002 (0.008)	0.09±0.002 (0.008)	0.09±0.002 (0.008)	0.10±0.003 (0.011)	0.10±0.001 (0.005)	0.11±0.004 (0.013)	0.12±0.002 (0.008)	0.11±0.003 (0.011)
AF	0.24±0.006 (0.021)	0.26±0.004 (0.013)	0.27±0.006 (0.020)	0.25±0.006 (0.021)	0.25±0.005 (0.017)	0.28±0.011 (0.035)	0.27±0.013 (0.041)	0.28±0.005 (0.017)
MF	0.27±0.012 (0.039)	0.28±0.008 (0.026)	0.29±0.006 (0.021)	0.30±0.006 (0.019)	0.29±0.009 (0.028)	0.28±0.007 (0.024)	0.29±0.007 (0.023)	0.30±0.005 (0.018)
F	0.72±0.018 (0.059)	0.72±0.018 (0.057)	0.73±0.018 (0.058)	0.80±0.017 (0.053)	0.85±0.031 (0.099)	0.85±0.021 (0.066)	0.85±0.013 (0.043)	0.88±0.013 (0.042)
Ti	0.64±0.008 (0.026)	0.64±0.009 (0.029)	0.62±0.007 (0.024)	0.67±0.012 (0.040)	0.71±0.009 (0.029)	0.71±0.013 (0.044)	0.67±0.018 (0.057)	0.76±0.014 (0.046)
E	1.73±0.046 (0.146)	1.59±0.029 (0.516)	1.80±0.019 (0.060)	1.83±0.042 (0.135)	1.62±0.037 (0.118)	1.70±0.031 (0.100)	1.67±0.059 (0.187)	1.71±0.027 (0.086)
O	0.15±0.002 (0.007)	0.14±0.002 (0.009)	0.14±0.005 (0.015)	0.15±0.004 (0.014)	0.15±0.002 (0.006)	0.15±0.004 (0.013)	0.15±0.001 (0.005)	0.16±0.004 (0.013)
Oh	0.10±0.001 (0.005)	0.11±0.001 (0.005)	0.10±0.001 (0.005)	0.12±0.003 (0.012)	0.11±0.002 (0.005)	0.11±0.002 (0.007)	0.10±0.002 (0.006)	0.12±0.003 (0.011)
A	0.71±0.013 (0.043)	0.73±0.006 (0.020)	0.72±0.010 (0.032)	0.72±0.013 (0.040)	0.06±0.014 (0.046)	0.59±0.013 (0.042)	0.66±0.014 (0.045)	0.62±0.018 0.057

B = Length of body
C = Max. width of head
M = Min. width of pronotum
Mx = Max. width of pronotum
P = Length of pronotum
H = Height of pronotum
V = Width vertex between eyes
D = Perpendicular distance
AF = Length of anterior femur
MF = Length of middle femur
F = Length of posterior femur
Ti = Length of posterior tibia
E = Length of elytron
O = Vertical diameter of eye
Oh = Horizontal diameter of eye
A = Length of antenna

The measurements of different body parts *i.e.*, body length, maximum width of head, minimum and maximum width of pronotum, length and height of pronotum, width vertex between eyes, perpendicular distance, length of anterior, middle and posterior femur, length of posterior tibia, length of elytron, vertical diameter of eye, horizontal diameter of eye and length of antenna for both male and female were compared to each other on each experimental set-up including different temperatures and foods. The data (Table 1 & 2) indicated that all body parameters, except few (*i.e.*, length, height and width of pronotum, vertex between eyes, perpendicular distance, vertical and horizontal diameter of eye) showed a significant difference with respect to various experimental set up.

When the standard errors of means of the 16 selected body parts measurements in adults were compared at two different temperature (27±1 & 37±1°C) and also on different food (*Zea mays* and *Cynodon dactylon*), it was found that in all cases, these were very less different as compared with their respective means. Hence, the mean values can be used as reliable estimates of the phase indices. Further when all these measurements of *Oedaleus abruptus* were statistically analyzed, it was observed that all of them follow specific pattern of growth and development for different experimental conditions (food and temperatures). Since direct measurements found inadequate for determination of the hidden 'locust in making' behaviour by simple statistical methods. The selected measurements used in present investigations to get ratios on the pattern established by Uvarov (1921, 1966).

Table 3. Mean ratios and standard error in crowded and isolated conditions for adults of *O. abruptus* at 37±1°C fed on *Zea mays* and *Cynodon dactylon*

Symbols	*Zea mays*				*Cynodon dactylon*			
	Males		Females		Males		Females	
	Crowded	Isolated	Crowded	Isolated	Crowded	Isolated	Crowded	Isolated
P/C	1.28±0.034 (0.107)	1.28±0.024 (0.077)	1.31±0.034 (0.107)	1.32±0.025 (0.079)	1.22±0.042 (0.133)	1.27±0.045 (0.143)	1.24±0.033 (0.105)	1.20±0.026 (0.082)
E/F	1.92±0.33 (0.101)	2.06±0.028 (0.088)	1.68±0.042 (0.134)	1.70±0.011 (0.036)	2.50±0.083 (0.264)	2.29±0.077 (0.245)	1.96±0.065 (0.207)	1.94±0.040 (0.127)
F/C	3.49±0.089 (0.281)	3.21±0.048 (0.152)	3.12±0.065 (0.207)	3.19±0.047 (0.150)	2.84±0.101 (0.319)	3.13±0.071 (0.026)	2.96±0.118 (0.375)	2.89±0.026 (0.081)
F/P	2.75±0.063 (0.199)	2.51±0.033 (0.104)	2.40±0.048 (0.153)	2.44±0.040 (0.126)	2.35±0.078 (0.248)	2.49±0.093 (0.295)	2.38±0.058 (0.184)	2.41±0.054 (0.170)
F/O	5.84±0.156 (0.493)	5.78±0.064 (0.201)	5.60±0.171 (0.539)	6.20±0.097 (0.307)	5.43±0.215 (0.681)	5.28±0.192 (0.606)	5.83±0.086 (0.273)	5.48±0.131 (0.414)
Ti/C	3.11±0.088 (0.277)	2.82±0.072 (0.229)	2.81±0.066 (0.208)	2.78±0.057 (0.183)	2.42±0.079 (0.249)	2.62±0.052 (0.165)	2.33±0.083 (0.264)	2.48±0.035 (0.111)
Ti/F	0.89±0.010 (0.033)	0.88±0.021 (0.066)	0.90±0.007 (0.024)	0.87±0.014 (0.045)	0.85±0.022 (0.069)	0.84±0.006 (0.018)	0.79±0.025 (0.078)	0.86±0.010 (0.033)
Ti/P	2.44±0.054 (0.172)	2.21±0.055 (0.173)	2.16±0.041 (0.129)	2.12±0.049 (0.157)	1.99±0.026 (0.084)	2.08±0.075 (0.237)	1.87±0.029 (0.094)	2.07±0.048 (0.151)
Ti/O	1.59±0.127 (0.402)	5.06±0.097 (0.308)	5.04±0.155 (0.491)	5.41±0.154 (0.489)	4.67±0.167 (0.528)	4.42±0.156 (0.492)	4.62±0.138 (0.437)	4.69±0.074 (0.233)
E/Ti	2.15±0.36 (0.113)	2.36±0.63 (0.199)	1.87±0.058 (0.182)	1.96±0.039 (0.122)	2.92±0.033 (0.103)	2.74±0.086 (0.272)	2.49±0.116 (0.369)	2.26±0.051 (0.161)

P/C = Length of pronotum to max. width of head
E/F = Length of Elytron to length of hind femur
F/C = Length of hind femur to max. width of head
F/P = Length of hind femur to length of pronotum
F/O = Length of hind femur to vertical diameter of eye
Ti/C = Length of hind tibia to max. width of head
Ti/F = Length of hind tibia to length of hind femur
Ti/P = Length of hind tibia to length of pronotum
Ti/O = Length of hind tibia to vertical diameter of eye
E/Ti = Length of elytron to length of hind tibia

A number of ratios (between length of pronotum and maximum width of head, length of elytron and length of hind femur, length of hind femur and maximum width of head, length of hind femur and length of pronotum, length of hind femur and vertical diameter of eye, length of hind tibia and maximum width of head, length of hind tibia and length of hind femur, length of hind tibia and length of pronotum, length of hind tibia and vertical diameter of eye, length of elytron and length of hind tibia) of *O. abruptus* were tested at different conditions, and most promising were those between two measurements, which vary in opposite directions according to the rearing condition and their hidden phase, but in the same direction for both sexes. Such differences in ratios are likely to show the hidden instinct of 'locust in making' more clearly.

The data (Tables 3 & 4) clearly indicated that the variation in different body ratio of *O. abruptus* was quite evident with change in the temperature, food as well as phage (crowded and isolated) and also showed corroboration with the suggestions of Uvarov (1921, 1966) and Albrecht (1953).

Table 4. Mean ratios and standard error in crowded and isolated conditions for adults of *O. abruptus* at 27±1°C fed on *Zea mays and Cynodon dactylon*

Symbols	*Zea mays*				*Cynodon dactylon*			
	Males		Females		Males		Females	
	Crowded	Isolated	Crowded	Isolated	Crowded	Isolated	Crowded	Isolated
P/C	1.29±0.030 (0.096)	1.24±0.028 (0.088)	1.29±0.060 (0.189)	1.37±0.057 (0.181)	1.25±0.032 (0.100)	1.17±0.043 (0.135)	1.26±0.045 (0.141)	1.26±0.037 (0.117)
E/F	2.42±0.089 (0.282)	2.24±0.086 (0.271)	1.93±0.092 (0.289)	2.02±0.075 (0.236)	2.03±0.072 (0.228)	2.03±0.042 (0.132)	1.76±0.032 (0.100)	1.723±0.052 (0.166)
F/C	2.96±0.082 (0.259)	2.93±0.088 (0.278)	2.93±0.126 (0.398)	3.12±0.134 (0.423)	3.36±0.071 (0.226)	3.33±0.083 (0.262)	3.15±0.082 (0.260)	3.15±0.081 (0.255)
F/P	2.30±0.083 (0.199)	2.36±0.071 (0.225)	2.30±0.110 (0.348)	2.30±0.085 (0.270)	2.70±0.075 (0.236)	2.87±0.088 (0.279)	2.52±0.099 (0.312)	2.51±0.055 (0.175)
F/O	4.84±0.146 (0.461)	5.04±0.126 (0.401)	5.56±0.209 (0.663)	5.79±0.195 (0.616)	5.74±0.142 (0.449)	5.94±0.163 (0.517)	6.50±0.202 (0.638)	6.29±0.248 (0.785)
Ti/C	2.64±0.051 (0.161)	2.64±0.082 (0.260)	2.43±0.054 (0.172)	2.64±0.122 (0.386)	2.57±0.072 (0.228)	2.95±0.108 (0.341)	2.43±0.054 (0.171)	2.59±0.093 (0.295)
Ti/F	0.90±0.022 (0.071)	0.91±0.028 (0.089)	0.84±0.031 (0.099)	0.85±0.029 (0.093)	0.68±0.031 (0.098)	0.88±0.021 (0.066)	0.77±0.013 (0.041)	0.82±0.017 (0.054)
Ti/P	2.06±0.058 (0.185)	2.12±0.052 (0.166)	1.91±0.056 (0.177)	1.94±0.058 (0.185)	2.07±0.073 (0.229)	2.54±0.102 (0.322)	1.96±0.111 (0.350)	2.06±0.069 (0.221)
Ti/O	4.31±0.094 (0.298)	4.55±0.136 (0.433)	4.62±0.134 (0.424)	4.88±0.120 (0.381)	4.41±0.178 (0.564)	5.24±0.145 (0.458)	5.01±0.139 (0.440)	5.19±0.283 (0.894)
E/Ti	2.70±0.089 (0.283)	2.48±0.073 (0.283)	2.30±0.057 (0.181)	2.38±0.037 (0.118)	2.65±0.093 (0.294)	2.31±0.072 (0.227)	2.28±0.029 (0.092)	2.11±0.085 (0.268)

P/C = Length of pronotum to max. width of head
E/F = Length of Elytron to length of hind femur
F/C = Length of hind femur to max. width of head
F/P = Length of hind femur to length of pronotum
F/O = Length of hind femur to vertical diameter of eye
Ti/C = Length of hind tibia to max. width of head
Ti/F = Length of hind tibia to length of hind femur
Ti/P = Length of hind tibia to length of pronotum
Ti/O = Length of hind tibia to vertical diameter of eye
E/Ti = Length of elytron to length of hind tibia

The difference in the means of ratios between crowded and isolated *O. abruptus* adults of the same experimental setup was found significant and at few places it was highly significant for both the sexes (Tables 5-6).

Table 5. Differences between means of ratios in crowded and isolated conditions for adults of *O. abruptus* at different temperatures on *Zea mays*

Symbols	37±1°C								27±1°C							
	Crowded males–Isolated males				Crowded females – Isolated females				Crowded males–Isolated males				Crowded females – Isolated females			
	Difference	t	d.f.	P	Difference	t	d.f.	P	Difference	t	d.f.	P	Difference	t	d.f.	P
P/C	–0.004	–0.281	29	0.780	–0.008	–0.321	29	0.750	0.046	2.267	29	0.031	–0.079	–1.809	29	0.080
E/F	–0.143	–6.265	29	0.000	–0.020	–0.854	29	0.399	0.175	2.153	29	0.039	–0.090	–1.157	29	0.256
F/C	0.279	5.654	29	0.000	–0.073	–1.429	29	0.164	0.035	0.515	29	0.610	–0.184	–1.631	29	0.114
F/P	0.230	7.913	29	0.000	–0.038	–1.053	29	0.301	–0.056	–1.213	29	0.235	0.009	0.096	29	0.924
F/O	0.058	0.598	29	0.554	–0.598	–5.801	29	0.000	–0.207	–1.637	29	0.112	–0.235	–1.287	29	0.208
Ti/C	0.292	4.806	29	0.000	0.026	0.582	29	0.565	0.003	0.062	29	0.951	–0.208	–3.236	29	0.003
Ti/F	0.013	0.913	29	0.369	0.028	3.427	29	0.003	–0.008	–0.520	29	0.607	–0.010	–0.333	29	0.740
Ti/P	0.237	5.259	29	0.000	0.034	0.785	29	0.439	–0.065	–1.803	29	0.082	–0.027	–0.573	29	0.571
Ti/O	0.128	1.317	29	0.198	–0.370	–2.978	29	0.006	–0.238	–2.589	29	0.015	–0.264	–3.519	29	0.001
E/Ti	–0.206	–7.096	29	0.000	–0.087	–2.314	29	0.028	0.222	3.355	29	0.002	0.082	–2.741	29	0.010

Table 6. Differences between means of ratios in crowded and isolated conditions for adults of *O. abruptus* at different temperatures on *Cynodon dactylon*

Symbols	37±1°C								27±1°C							
	Crowded males–Isolated males				Crowded females – Isolated females				Crowded males–Isolated males				Crowded females – Isolated females			
	Difference	t	d.f.	P	Difference	t	d.f.	P	Difference	t	d.f.	P	Difference	t	d.f.	P
P/C	0.077	2.270	29	0.031	0.001	0.030	29	0.976	–0.050	–1.953	29	0.060	0.037	1.975	29	0.058
E/F	0.011	0.026	29	0.979	0.041	2.625	29	0.014	0.206	3.194	29	0.003	0.024	0.543	29	0.591
F/C	0.027	0.581	29	0.565	0.004	–0.068	29	0.946	–0.293	–4.999	29	0.000	0.066	0.999	29	0.325
F/P	–0.165	–2.648	29	0.013	0.010	0.222	29	0.825	–0.146	–2.180	29	0.037	–0.031	0.619	29	0.540
F/O	–0.200	–2.088	29	0.045	0.210	0.952	29	0.349	0.146	0.956	29	0.347	0.354	3.519	29	0.001
Ti/C	–0.375	–4.709	29	0.000	–0.164	–2.711	29	0.011	–0.204	–5.912	29	0.000	–0.148	–3.718	29	0.001
Ti/F	–0.113	–4.780	29	0.000	–0.048	–4.981	29	0.000	0.017	1.292	29	0.206	–0.065	–3.746	29	0.001
Ti/P	–0.464	–8.392	29	0.000	–0.108	–1.999	29	0.055	–0.095	–2.904	29	0.045	–0.191	–4.889	29	0.000
Ti/O	–0.826	–8.418	29	0.000	–0.178	–0.942	29	0.354	0.201	1.928	29	0.064	–0.069	–1.045	29	0.304
E/Ti	0.347	5.267	29	0.001	–0.175	4.655	29	0.000	0.184	3.933	29	0.000	0.233	3.007	29	0.005

Table 7. Differences between means of ratios in crowded and isolated conditions for adults of *O. abruptus* at different temperatures on *Zea mays*

Symbols	37±1°C								27±1°C							
	Crowded males–Isolated males				Crowded females – Isolated females				Crowded males–Isolated males				Crowded females – Isolated females			
	Difference	t	d.f.	P	Difference	t	d.f.	P	Difference	t	d.f.	P	Difference	t	d.f.	P
P/C	–0.029	–1.310	29	0.200	–0.034	–3.856	29	0.000	0.032	1.267	29	0.215	–0.122	–3.605	29	0.001
E/F	0.234	7.884	29	0.000	0.358	25.795	29	0.000	0.468	7.057	29	0.000	0.224	3.988	29	0.000
F/C	0.373	5.029	29	0.000	0.021	0.806	29	0.427	0.014	0.242	29	0.811	–0.189	–1.907	29	0.006
F/P	0.348	7.598	29	0.000	0.079	3.634	29	0.001	–0.049	–0.989	29	0.311	0.064	1.204	29	0.238
F/O	0.239	2.171	29	0.038	–0.417	5.735	29	0.000	0.904	–8.466	29	0.000	–0.751	–5.055	29	0.000
Ti/C	0.301	4.789	29	0.000	0.035	1.178	29	0.248	0.277	5.673	29	0.000	–0.000	–0.001	29	0.999
Ti/F	–0.010	–2.015	29	0.053	0.006	0.846	29	0.404	0.087	4.322	29	0.000	0.056	3.915	29	0.000
Ti/P	0.286	7.952	29	0.000	0.082	3.208	29	0.003	0.172	4.247	29	0.000	0.188	4.375	29	0.000
Ti/O	0.152	1.680	29	0.103	–0.345	–5.785	29	0.000	–0.308	–3.056	29	0.005	–0.331	–3.137	29	0.004
E/Ti	0.283	9.865	29	0.000	0.401	17.923	29	0.000	0.278	3.435	29	0.002	0.104	2.284	29	0.029

Table 8. Differences between means of ratios in crowded and isolated conditions for adults of *O. abruptus* at different temperatures on *Cynodon dactylon*

Symbols	37±1°C								27±1°C							
	Crowded males–Isolated males				Crowded females – Isolated females				Crowded males–Isolated males				Crowded females – Isolated females			
	Difference	t	d.f.	P	Difference	t	d.f.	P	Difference	t	d.f.	P	Difference	t	d.f.	P
P/C	–0.013	–0.408	29	0.666	–0.089	–3.140	29	0.004	–0.025	–0.874	29	0.389	0.035	1.433	29	0.163
E/F	0.263	9.212	29	0.000	0.303	6.969	29	0.000	0.538	9.191	29	0.000	0.299	6.149	29	0.000
F/C	0.212	4.664	29	0.000	0.181	3.429	29	0.002	–0.116	–1.344	29	0.189	0.279	6.583	29	0.000
F/P	0.183	2.399	29	0.023	0.358	5.222	29	0.000	–0.031	–0.702	29	0.488	0.170	2.986	29	0.006
F/O	–0.759	–6.618	29	0.000	–0.348	–2.325	29	0.027	–0.406	–3.150	29	0.004	–0.151	–1.431	29	0.163
Ti/C	0.144	2.213	29	0.034	0.355	5.385	29	0.000	0.084	1.329	29	0.194	0.144	4.458	29	0.000
Ti/F	–0.003	–0.173	29	0.864	0.062	3.829	29	0.001	0.060	3.763	29	0.001	–0.029	–2.812	29	0.009
Ti/P	0.115	1.408	29	0.169	0.472	6.709	29	0.000	0.114	4.481	29	0.000	0.069	1.805	29	0.081
Ti/O	–0.604	–3.956	29	0.000	0.048	0.289	29	0.774	–0.007	0.049	29	0.961	–0.280	–4.045	29	0.000
E/Ti	0.367	6.549	29	0.000	0.195	3.478	29	0.002	0.429	5.784	29	0.000	0.435	8.921	29	0.000

The differences of ratios between two sexes of similar rearing condition taken, it was again found highly significant statistically except in a few occasions (Tables 7-8). The difference of means in crowded and isolated males and the difference between crowded and isolated females were statistically analysed, nearly in all cases it was highly significant except E/Ti that was found non-significant at few places.

All ratios were found statistically significant but F/C and E/F found quite promising as it is evident from the present analysis. The standard value for both of these ratios for solitary, transiens and gregarious phases given below:

Standard Morphometrical Ratios:

Phase	F/C	E/F
Solitary	3.75 or above	2.05 or below
Transiens	3.16 – 3.74	2.06 – 2/15
Gregarious	3.15 or below	2.16 or above

The results obtained for these ratios in different experimental set-ups compared with standard values for F/C and E/F and found significantly very close to transiens and gregarious phase in the experimental set-ups with high temperature. Dirsh (1951) evaluated the percentage of morphological gregarization by dividing the difference between standard values for gregarious and solitary phase by 100 individuals. Similarly F/C and E/F ratios in the present study were subjected to this calculation for both species and showed similarity with established locust species as was suspected for their hidden locust in making instinct. The percentage of gregarization is given in table 9, in their respective rearing condition.

Table 9. Percentage of gregarization in *Oedaleus abruptus* at different rearing conditions

Body parts ratios	F/C		E/F	
Rearing condition	♂	♀	♂	♀
Crowded/*Zea mays*/37°C	43	-	-	-
Isolated/ *Zea mays* /37°C	90	94	18	-
Crowded/*Cynodon*/37°C	-	-	-	-
Isolated/*Cynodon*/37°C	-	-	-	-
Crowded/ *Zea mays* /27°C	-	-	-	-
Isolated/ *Zea mays* /27°C	-	-	-	-
Crowded/*Cynodon*/27°C	65	-	1	-
Isolated/*Cynodon*/27°C	69	99	1	-

The results obtained from the present study on the morphometrics of different body parts and their ratios under different experimental set-ups revealed significant evidence that species of grasshopper under study may turn to gregariousness when get conducive environmental condition. The different experimental condition also influenced the variation in morphometric measurements and species behave like established locusts.

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Biosystematics of aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) from Asir Region of Saudi Arabia

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Abstract

The present study deals with records on aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) of Asir region, Saudi Arabia. The specimen collected from aphid colonies on wild and cultivated plants, were identified in the laboratory of the department of Biology, King Khalid University, Abha. The findings revealed that five species belonging to four genera *viz.*, *Aphidius colemani* Viereck, *Aphidius matricariae* Haliday, *Diaeretiella rapae* (M´Intosh, 1855), *Pauesia* sp. and *Praon exsoletum* (Nees, 1811) recorded for the first time from this region.

1. INTRODUCTION:

Aphids are considered as major pests in many agricultural systems throughout the world. They damage directly by feeding and indirectly as a vector of certain plant diseases (Ali and Rizvi, 2007). Among the natural enemies of aphids, aphidiinae parasitoids are key component, which helps to control aphid population in varieties of crops (Stary, 1988). The Aphidiines are small hymenopteran parasitoids belongs to subfamiliy Aphidiinae of the family Braconidae. They are solitary endoparasitoids of aphids and their size varies from about two to five millimeters. The taxonomy of the group includes about 50 genera and subgenera and approximately over 600 species distributed globally (Sanchis et al., 2001).

The aphiidinae parasitoid fauna of Asir region or rather largely Saudi Arabia is remained unexplored. In spite of recent studies in the adjoining parts of Arabian peninsula (North Africa, Mediterranean region and Central Asia), several areas still remain unexplored as a result of which there are huge gaps in our knowledge of aphidiinae distributions in this area. Several taxonomical studies on aphidiinae parasitoids, as well as on its aphid-plant associations, have been carried out in adjacent areas. A general information is as follows: Israel (Mescheloff and Rosen, 1988a,b; 1990a,b; 1993), Turkey (Aslan et al., 2004; Güz and Kilincer, 2005; Uysal et al., 2004), Southeastern Europe (Kavallieratos et al., 2001, 2004), Iraq (Starý and Kaddou, 1975), Iran (Starý, 1979; Starý et al., 2000, 2005; Rakhshani et al., 2005, 2006, 2007a,b, 2008a,b; Tomanovic et al., 2007; Talebi et al., 2009; Barahoei et al., 2010; Jafari-Ahmabadi et al., 2011; Mossadegh et al., 2011).

One of the reasons for the great diversity in the area is an amazing array of habitats from dense juniper forest at 3000 m, to low land costal line with sufficient cultivated area. This area remains one of a few places globally, which may still harbour species of aphidiines yet unknown to science. From this region, very few papers on the parasitoid fauna reported specially from Yemen (Erdelen, 1981; Starý and Erdelen, 1982). Therefore, present study has been carried out to fill the gaps of aphid-parasitoids particularly on aphidiinae from Saudi Arabia.

2. MATERIALS AND METHODS:

The specimens were collected from wild and cultivated plants bearing aphid colonies along with parasitoids from several parts of Asir region of Saudi Arabia (Fig. 1). The samples were directly placed within the plastic vials (sized 3 x 5 cm) covered with fine mesh cloth and brought to the laboratory for rearing. After 20-25 days, parasitoids completed their development and emerged from the aphid bodies. The parasitoids emerged from aphid host were transferred to 96% ethyl alcohol for preservation and future identification. The sample data were arranged with the objective of developing a tri-trophic database. In each numbered sample, the information about location, date, aphid, plant and habitat was recorded. The detailed description along with types

of identified specimens was deposited in the insect collection of the department of Biology at King Khalid University, Abha, Kingdom of Saudi Arabia.

Fig. 1. Map of the sampling areas at various parts of Asir region in Saudi Arabia.

3. RESULTS:

A total of five aphidiinae parasitoids species belonging to four genera are recorded for the first time from Saudi Arabia.

3.1. *Aphidius colemani* Viereck, 1912

Material examined: 9 female and 3 male, KSA: Abha, 10. V. 2012, *Aphis craccivora* Koch on *Vigna* sp. (coll. Z. Ahmad); 11 female and 4 male, KSA: Abha, 10. IX. 2012, *Aphis craccivora* Koch on *Vigna* sp. (coll. Z. Ahmad); 3 male, KSA: Abha, 10. VI. 2010); *Myzus persicae* (Sulz.) on *Solanum* sp. (coll. Z. Ahmad).
Unknown host material: 2 female; KSA: Raidah, 24. IV. 2011, mal. Trap; 1 male, KSA: Qunfudah, 2. V. 2011, mal. Trap.
Note – A broadly oligophagous species**,** *Aphis*, *Brachycaudus*, *Myzus*, *Rhopalosiphum*-species.

3.2. *Aphidius matricariae* Haliday, 1834

Material examined: 17 female and 9 male, KSA: Abha, KKU University campus 10. IV. 2012, *Aphis gossypii* Glover on *Aster* sp. (coll. Z. Ahmad)
Unknown host material: 5 female, KSA: Raidah, 7. IV. 2010, mal. Trap; 3 female, KSA: Qunfudah, 14. III. 2010, mal. Trap.
Note – A broadly oligophagous parasitoid on *Aphis*, *Diuraphis*, *Myzus.*

3.3. *Diaeretiella rapae* (M´Intosh, 1855)

Unknown host material: 7 female and 5 male, KSA: Al Soudah, 16. IX. 2011, net sweeping (coll. Z. Ahmad)
Note – A parasitoid of *Brevicoryne brassicae*, *Lipaphis pseudobrassicae*, *Myzus persicae*, less frequently on *Rhopalosiphum maydis*, *R. padi* and *Schizaphis graminum*.

3.4. *Pauesia* sp.

Unknown host material: 3 female, KSA: Raidah, 23. IV. 2010, mal. Trap.
Note – A parasitoid of *Cinara* species on conifers.

3.5. *Praon exsoletum* (Nees, 1811)

Unknown host material: 13 female and 1 male, KSA: Abha, wadi johan, 29. X. 2011, net sweeping on agricultural field; 3 female, KSA: Abha, wadi johan 17. X. 2011, net sweeping on agricultural field.
Note – A parasitoid of *Therioaphis* species.

4. DISCUSSION:

The south-west of Arabia (Asir) is the stronghold of the Arabian endemic flora. The region has a wide diversity of vegetation and topography. Altitude reaches from low land tihama region along costal area of red sea to just over 3,000 m highlands at Jabel al-Soudah and Raidah. The natural forest of juniper *Juniperus procera* in the highlands is probably the most extensive anywhere in Arabia. Also in the highlands, there are thickly wooded *Acacia* valleys of various species but *Acacia tortilis* and *A. mellifera* were the most common noted during the present survey. Terraced agriculture growing cereals, notably wheat (being harvested in July) and maize (harvested in September to October) is predominant in this

region. Apart from this there are several fruits growing orchards like pomegranates, peaches and apricot also present in this region. In the foothills below 1,500 m vegetation becomes much more Afro tropical with numerous *Ficus* trees and genera such as *Aloe*, *Commiphora*, *Ceropegia* and *Caralluma* being well represented. These lusher habitats of the foothills soon give way on the lowland costal area (Tihama) along red sea to arid sandy deserts interspersed with very fertile irrigated fields where water runoff from the highlands can be controlled or where water is close to the surface. These tilled areas usually have high bunds around them and grow a variety of crops like *Saccharum*, *Sorghum bicolor, Solanum lycopersicum, Pennisetunm spicatum, Nicotiana tabacum, Trifolium alexandrinum, Citrullus vulgaris*, *Gossypium* sp., *Zea mays* etc.

Despite being an important hotspot region, studies related biodiversity of aphidiinae insect community are totally neglected. Although aphidiinae parasitoids have major importance in the biological control of aphid pests. Therefore, knowledge of present paper on the biodiversity and biosystematics of Aphidiinae parasitoids provide basic and more essential information to evaluate them in the classical biological control programme of aphids. Further studies on mass production and field evaluation these parasitoids to manage aphids on different agricultural crops in the southern region of Saudi Arabia is needed.

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Management of African bollworm *Helicoverpa armigera* (Lepidoptera: Noctuidae) in Chickpea crop at State of Eritrea

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Abstract

The field study was conducted in Hamelmalo Agricultural College in State of Eritrea by using pesticides *i.e.* Cloropyriphos, cypermethrin and neem seed kernel. The findings revealed that all the treatments were significantly reduced the population of African bollworm in chickpea crop. Both chemical insecticides Cypermethrin and Cloropyriphos were more effective in comparison of Neem Seed Kernel. The percent reduction of African bollworm in every plot was considerable and remarkable, documented yield of chickpea 380.36g/plot, 390.26g/plot 297.22g/plot and 283.87g/plot in Cypermethrin, Cloropyriphos, neem seed and control plot, respectively. Neem seed extract was effective than control, even if it was not as much as the chemical insecticides.

1. INTRODUCTION:

Chickpea or Bengal gram (*Cicer arentium*) is the most important pulse crop, in many countries of the world. It probably originated in South Eastern Turkey and adjoining Syria. The cultivation of this crop is about 8.57 million tones in 10.4 million hectares area with a productivity of 824 kg ha^{-1} throughout the globe. As many as 45 countries, including Eritrea, are growing chickpea and threaten by the attack of *Helicoverpa armigera* (Gowda, 2005). Besides chickpea it is also attack on cotton, maize, pigeonpea and a range of oilseeds, vegetables and fruit crops distributed in Asia, Africa, Australia and the Mediterranean Europe. The worldwide loss in chickpea and pigeonpea alone due to attack of *H. armigera* is recorded as US$ 927 million and possibly over US$ 5 billion on other crops (Sharma, 2001).

In state of Eritera, the economic losses in chickpea is estimated about 50 %, which increase upto 100 % due to favorable conditions for *H. armigera*, particularly in the state where frequent rain and cloudy weather is prevailing during croping season (Patel, 1979; Shengal and Ujagir, 1990; Sachan and Katti, 1994). About 80 percent Eritrean population are farmer and majority of them producing chickpea and using by different means. The effort has therefore, been made to protect the loss of chickpea from African bollworm by using of chemical and neem based insecticides.

2. MATERIALS AND METHODS:

2.1. Field preparation and raising of chickpea crops:

Field was prepared by using the tractor with harrow and cultivator. Three ploughings were done and each one followed by planking in order to make soil fine. The experiment was laid out in randomized complete block design (RCBD) with three replications. Each treatment was randomly allotted in every block. The unit plot size was 3 x 3 m with a distance of 0.3 m between the plots and 150 cm between the replications. The local variety of chickpea was sown in first fore night of November, 2011.

2.2. Preparation of treatments:

For preparation of treatments cypermethrin 25 EC and Cloropyriphos 25 EC was prepared as 1.5 ml/l. Similarly, for neem seed extract, dried seed plant materials were taken from the laboratory of the Department of Plant Protection, Hamelmalo Agriculture College. The neem seed have peeled from the seed coat and 100 g neem seed was pound gently in mortar with pestle, and thereafter soaked in 200 ml water. The soaked material was squeezed through muslin cloth and mixed with 10 g of soap.

2.3. Statistical analysis:

The data collected were analyzed by the application of software GENESTAT and Sigma plot followed by analysis of variance (ANOVA) and subjected to test of significance by Duncan's multiple range test (DMRT).

3. RESULTS AND DISCUSSION:

Before first application, the larvae of *H. armigera* were counted in every plot of chickpea. The average number of larvae per plant observed as 5.33, 5.21, 4.95 and 5.50 larvae/plant with respect to each treatments (Cloropyriphos, Cypermethrin, Neem seed kernel and Control) (Table 1). The respective population was again counted as 2.08, 2.00, 4.53 and 10.79 larvae/plant after 24hr of spraying. It was recorded that larvae decreased in every plot in comparison of control treatment. Among different treatments, cypermethrin was found as most effective with highest percent reduction of 61.55 (Table 1). The present observations are well supported by Chaudhary and Sachan (1995), they reported cypermethrin was highly effective against pod borer on chickpea.

The observations again recorded with respect to second application of insecticides, since the larval population again reached beyond the economic injury level and counted as 4.59, 4.65, 4.91 and 5.81 with respect to Cloropyriphos, Cypermethrin, Neem seed kernel and Control plot (Table 1). After second application, the larvae of *H. armigera* reduced significantly in treated plots, where as a high population was documented in the untreated control plots. Here, chloropyriphos found significant to reduce population of *H. armigera* and it was followed by treatment of cypermethrin, whereas, neem seed karnel was inferior after the control (Table 1). However, Bajpai and Sehgal (2000) reported that neem based insecticides like nimbicidine and phytoproducts like neem oil and tobacco leaf extract were moderately effective, although it was inferior to HNPV on chickpea. In addition, Rahman (1991) recommended management strategies of *H. armigera* from Bangladesh and advised synthetic insecticides were effective than neem based products, which again provide further strengthen to the present findings.

While documenting yield performance of chickpea with respect to treatments, the result showed a significant difference in average yield (Table 1). The highest yield was recorded by applying chloropyrifos (390.26 g/plot) and lowest was in control (283.87 g/plot). However, the yield loss in chickpea due to pod borer was ranged from 10 to 60 percent in diverse weather conditions from different part of the world (Bhatt and Patel, 2001; Bhushan et al. (2011).

Table 1. Efficacy of chemical and neem insecticides on the population of *Helicoverpa armigera*

Treatments	No of Samples	First application			Second application			Average Yield (g/plot)
		Before Spray	After Spray	% Reduction	Before Spray	After Spray	% Reduction	
Cloropyriphos	10	5.33	2.08b	60.98	4.59	1.36c	70.37	380.36a
Cypermethrin	10	5.21	2.00b	61.55	4.65	2.06bc	55.70	390.26a
Neem seed kernel	10	4.95	4.53b	8.48	4.91	2.403b	51.09	297.22b
Control	10	5.50	10.79a	--	5.81	6.67a	--	283.87b
LSD 5%	--	--	3.80	--	--	0.70	--	72.62
C.V	--	28.62	29.98	--	11.34	6.72	--	10.75

The present finding concluded that every treatment is effective against African pod borer, *H. armigera* and both chemical insecticides *i.e.* Cloropyriphos, Cypermethrin are more effective than neem seed karnel.

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Assessment of age specific life parameters of whitefly, *Bemisia tabaci* Genn. (Homoptera: Aleyrodidae) on some preferred host plants

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Abstract

Survival and mortality of whitefly (*Bemisia tabaci* Genn.) has been studied on cotton, black gram and green gram under laboratory condition to find out the host preference. Findings revealed a significant variation in life parameters of whitefly with change in host plants. Although, shortest immature life (14.98±0.82 days) and adult survival (26 days) of whitefly was recorded on cotton as compared green gram and black gram. In addition, cotton plant was recorded as most favourable food of whiteflies with highest adult survival than other plants.

1. INTRODUCTION:

The sweet potato whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae) was described more than a century ago (Oliveira et al., 2001) and currently is one of 600 most invasive and destructive species on agricultural crops throughout the globe (Lowe et al., 2000; Kontsedalov et al., 2012). Due to small size, its detection on agricultural commodities is difficult, hence an invasion is reported from all the continents except countries having cold climate round the year (Dinsdale et al., 2010; Han et al., 2013). Consisting of over 30 biotypes (Liu et al. 2012; Chowda-Reddy et al., 2012), differing in biological attributes and preferences among each other, generally they feeds on phloem tissues of the host plants. Apart from phloem feeding, they are excreting honeydew and also evolve in vectoring viruses causing diseases in plants (Horowitz et al., 2002; Han et al., 2013). Along with virus transmission, insecticide resistance (Han et al., 2013) has posed a new challenge before the growers. A number of pest control agents *viz*., entomo-pathogenic fungi, natural enemies and pesticides, have been employed to manage this viral vector.

Any change in population structure or unexpected dynamics may affect the efficacy of above pest control methods, hence a thorough understanding of survival and mortality dynamics of whitefly, *B. tabaci* is required (Han et al., 2013). Therefore, an objective of this study was to investigate the biology, survival and mortality of whitefly affected by different host plants.

2. MATERIALS AND METHODS:

2.1. Culture of whiteflies:

Seeds of black gram (*Vigna mungo* L.), green gram (*V. radiata* L.) and cotton (*Gossypium hirsutum* L.) was sown in thermo-coal pots (sized 9 x 6 x 7 cm in top, bottom diameter and height) under laboratory conditions (temperature 26±3°C, RH: 75±5% and photo phase: 14hr) at Department of Protection, Faculty of Agricultural Sciences of Aligarh Muslim University, India. Fresh pupae of whitefly (*Bemisia tabaci* Genn.) were collected from the experimental field of the department, to obtain newly emerged adults. The culture was maintained up to four generations on brinjal (*Solanum melongena* L.) plant to get a laboratory adopted strain and F-5 generation was used in present investigation. To obtain fresh eggs, pairs of adult whitefly were released in confined plastic vials (4.20 x 2.00 x 1.70 x 2.20 cm in length, upper diameter, lower diameter and cap diameter) on under surface of leaves. These vials were provided with two square shape ventilation windows at either ventral sides, one at bottom and second one at neck opposite to that of bottom and a fine meshed cloth was pasted as screen on the windows (Fig. 1). After 24 hours of confined, exposure of male and female whitefly pairs, two eggs from each exposed leaf were selected and marked with black permanent and nontoxic marker and such leaves containing those of eggs were tagged at petiole region to facilitate the infestation identity, while rest of the eggs were get discarded. The whole amount of such tagged plants used under the study

were screened with fine meshed white cotton cloth to avoid further infestation of whitefly, mites or ants if there were any. This ensured that every leaf chosen remained with a specific number of eggs, all of which had been marked. A total of 100 plants were selected to give a cohort of 200 eggs and rest of the eggs and nymphs were discarded. Settled first-instar nymphs were identified and marked again by making a circle around. These first instars were identified by their translucent colour, small size, and characteristic ovoid shape. Marked nymphs were revisited after 1 hr to ensure that they had settled. Any nymph that had crawled out of the circle was replaced by marking new one on another leaf of a new plant. All cohorts in each plot were established on the same day, and were marked between 07:00 and 10:00 hours of the same day. When insect completed its immature life, the red eyed pupae/pseudo-pupae were identified and caged in vials (Fig. 1). Adult longevity, survival and mortality were observed subsequently. This study will provide essential gap filling information for devising effective management strategies for whitefly by providing information in areas having in vogue cultivation of above mentioned cotton and bean crops.

2.2. Data Analysis:

The below given assumptions were used for the documentation of age specific life-table.

x = age of the insect in days

l_x = number of individuals that survived at the beginning of each age interval x

d_x = number of individuals that died during the age interval x

$100q_x$ = per cent mortality, computed through the following equation:

$$100qx = [d_x / l_x] \times 100$$

e_x = expectation of life or mean life remaining for individuals of age x

Life expectation was calculated by using the equation

$$e_x = T_x / l_x$$

To obtain ex, two other parameters L_x and T_x were also computed as below

L_x = the number of individuals alive between age x and x+1 and calculated by the equation:

$$L_x = l_x + 1\ (x+1)/2$$

T_x = the total number of individuals of x age units beyond the age x and obtained by the equation:

$$T_x = l_x + (l_x + 1) + (l_x + 2) \ldots\ldots\ldots\ldots + l_w$$

Where, l_w = the last age interval

Fig. 1. Exposure of whiteflies through plastic vial

3. RESULTS:

All the host plants used to expose the whitefly responded varyingly (df-3, 11; $p \leq 0.05$) (Table 1). The biological parameters of whitefly reared on cotton were significantly different (df-2, 11; $p \leq 0.05$) from bean reared individuals whereas, the population fed on black gram and green gram did not exhibited a significant difference among each other (df-2, 11; $p \leq 0.05$) except the longevity of adult females. The immature life of *Bemisia* ranged from 14.98±0.82 days on cotton to 20.51±1.00 days on green gram. Females flies reared on all the host plants were long surviving than males (df-2, 11; $p \leq 0.05$) while the performance pattern was alike the immature stages. The maximum duration of adult male and female longevity (14.58±0.40 and 18.74±0.99 days) was observed on green gram with shortest respective duration (12.44±0.84 and 15.58±0.84 days) on cotton. The hatching took minimum duration (3.22±0.38 days) on cotton and maximum (4.95±0.20 days) on black gram followed by (4.92±0.18 days) green gram (Table 1). The longest pupal duration (4.22±0.22 days) was also recorded on green gram and the lowest on (3.74±0.46 days) cotton.

Table 1. Life parameters of whitefly (*B. tabaci*, Genn.) on different host plants

Host	Egg	I instar	II instar	III instar	Pupa	Total	Male	Female
Black gram	4.95±0.20^{b}	3.24±0.11^{b}	3.68±0.18^{b}	4.18±0.21^{b}	4.22±0.22^{b}	20.27±1.22^{b}	14.45±0.78^{b}	18.44±0.78^{b}
Green gram	4.92±0.18^{b}	3.26±0.14^{b}	3.72±0.13^{b}	4.45±0.27^{b}	4.16±0.22^{b}	20.51±1.00^{b}	14.58±0.40^{b}	18.74±0.99^{c}
Cotton	3.22±0.38^{a}	2.48±0.29^{a}	2.36±0.32^{a}	3.18±0.24^{a}	3.74±0.46^{a}	14.98±0.82^{a}	12.44±0.84^{a}	15.58±0.84^{a}

The age specific survival was of stair step like in pattern documenting shortest span (26 days) on cotton and the longest on green gram (Fig. 1). On the other hand, mortality of whitefly did not follow a regular/definite pattern on all the host plants. Maximum mortality of whitefly on black gram was recorded at first instar nymphal stage followed by pupal stage, while on green gram and cotton the corresponding peaks were observed at pupal stage of life. Overall highest survival percentage at all the immature stages was observed on cotton as compared to green gram and black gram (Fig. 2).

Fig. 1. Age specific survival and mortality of whitefly (*B. tabaci* Genn.) on different host plants

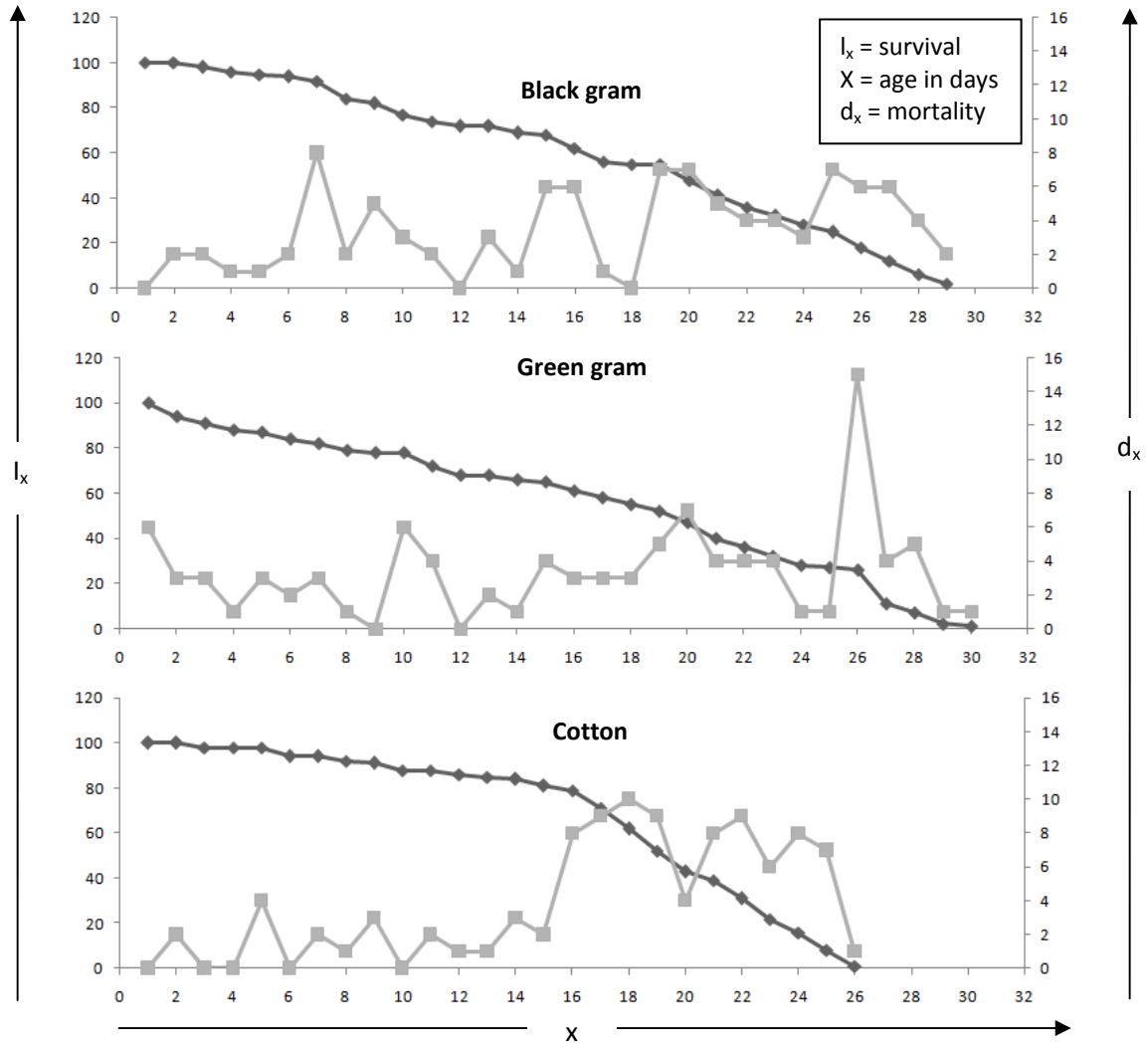
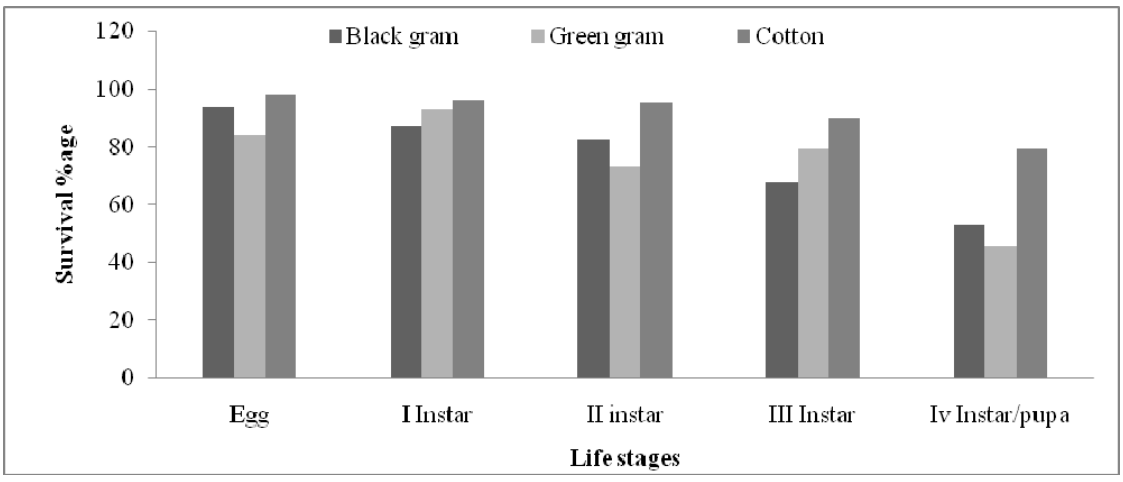


Fig. 2. Age specific survival (in percent) of whitefly (*B. tabaci*, Genn.) on different host plant



4. DISCUSSION:

The findings reveal that egg hatchability and nymphal survival was higher on cotton as compared to bean crops and the results are justified with the research work of Abdel Baky et al. (2004). The literature on biology and ecology from recent past shows that the development of immature *Bemisia tabaci* is dependent on type of whitefly population or biotype (Muniz and Nombela, 1997; Bonato et al., 2007) or host plants (Zalom et al., 1995; Tsai and Wang, 1996; Muniz and Nombela, 1997; Nava Camberos et al., 2001; Lin and Ren, 2005; Bonato et al., 2007).

The result shows that whitefly documented short life and high percentage of survival on cotton as compared to green gram and black gram and these outcomes has a great proximity with the findings of Abdel Baky et al. (2004). According to Van Lenteren and Noldus (1990) the host plant preference in case of whitefly (*Trialeurodes vaporariorum* West.) directly related to biological performance on the plant. Elevated rate of reproduction, low mortality rate and shorter development time of insects on a particular host has pointed toward greater suitability of a host plant (Costa et al., 1991a & b; Awmack and Leather, 2002; Hasan and Ansari, 2011).

In conclusion, whitefly (*B. tabaci* Genn.) has shown a greater host preference for cotton as compared to green gram and black gram by documenting a short life and a comparative lower mortality rate.

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Preliminary checklist of grasshoppers and locust fauna (Orthoptera: Acrididae) of Bihar, India

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Abstract

Grasshoppers and locusts are the members of family Acrididae, superfamaliy Acridoidea, sub-order Caelifera and order Orthoptera. They have been accredited as pests of field, pasture and forest as well. The present study focuses on the distribution of the concerned insect pests in Bihar. Survey has been conducted in thirty six districts of Bihar during the year 2009 and 2010, and thirty seven species of grasshoppers and locusts representing twenty nine genera, four tribes, twelve subfamilies and three families have been collected during investigations.

1. INTRODUCTION:

Acridoids have long been noted as pests of agriculture as well as forests. Hoppers and adults are equally damaging and are reputed defoliators. Defoliation being the most common mode of damage but some of the species, in case of severe outbreaks, even finishes up the ears of crops and comparatively softer stem portions. Bihar is one of the most important Eastern States of India and has notified forest area of 6,764.14 km² and is a vast stretch of fertile plain that consists of a thick alluvial mantle of drift origin overlying in most part. The natural vegetation of Bihar is moist deciduous forests, mostly found in northern and southern parts of the state. The average rainfall of Bihar is around 120 cm.

The work on collection of insect fauna was started in the period of British India (Kirby, 1914). The literature shows that Indian grasshoppers always have importance due to their outbreaks at different places (Bhowmik, 1985). Later on, study was conducted on collection of acridoid fauna from different part of India *i.e.* Uttarakhand (Hazra et al., 1993), Kashmir (Reshi et al., 2008), Himachal (Shishodia and Gupta, 2009), Jharkhand (Nayeem and Usmani, 2012a), Uttar Pradesh (Akhtar et al., 2012; Nayeem and Usmani, 2012b) etc. Such work in Bihar was neglected even though the state reserves rich agricultural potential and thereby the Superfamily Acridoidea of this region needs to be worked out. It is because of this reason that the entire state was surveyed and the result is the first systematic collection from the state.

2. MATERIALS AND METHODS:

2.1. Collection of Acridoids:

The acridoids (grasshoppers and locusts) were collected from various agricultural and pasture areas along with forest habitat of different districts of Bihar in the year 2009 and 2010. They were caught by ordinary aerial insect net and also by hands. The net was used by sweeping on grasses, bushes and other vegetables for collection of acridoids individually. The collected specimens were killed in cyanide bottles and brought to the laboratory for further investigation.

2.2. Stretching of Acridoids:

Dry mounts were also prepared for better understanding of certain characters like size, colour, texture etc. For this purpose, the specimens were first relaxed, stretched, and later they were pinned and labelled properly. Permanent collections of pinned specimens were kept in collection boxes.

2.3. Genitalic study of Acridoids:

The genitalia of grasshoppers and locusts remove from the body and passed through graded series of alcohol for preparation of permanent slides. Later on, slides were examined under the stereoscopic microscope in order to make a detailed study on the genitalic structures of acridoids. Drawings were initially made with the help of camera lucida and details were filled in by conventional microscope examination.

3. RESULTS AND DISCUSSION:

An extensive survey was conducted in different habitats of state Bihar. A total of two hundred seventy seven specimens of grasshoppers and locusts were collected, which sorted out to yield of thirty seven species, representing twenty nine genera, four tribes, twelve subfamilies and three families represented in table 1.

Table 1. Systematic account of grasshoppers and locusts collected from Bihar, India

S.No.	Name of Species, tribe, family	Specimen collected	Collection place in Bihar
	Super family: Acridoidea		
	Family: Pyrgomorphidae		
	Tribe: Atractomorphini		
1.	*Atractomorpha psittacena*	2♂, 2♀	Saran Chhapra, Purba Champaran, Motihari
2.	*Atractomorpha sinensis*	6♀	Gopalganj, Vaishali, Hajipur, Samastipur, Supaul
	Tribe Poikilocerini		
3.	*Poekilocerus pictus*	1♀	Banka
	Tribe Chrotogonini		
4.	*Chrotogonus trachypterus*	6♀	Khagaria, Gaya, Katihar, Samastipur, Paschim Champaran, Bettiah
	Family Catantopidae		
	Subfamily Oxyinae		
5.	*Oxya japonica japonica*	1♂, 30♀	Rohtas, Sarsaram, Aurangabad, Gaya, Araria
6.	*Oxya hyla hyla*	10♀	Gopalganj, Banka, Araria, Rohtas,
7.	*Oxya fuscovittata*	1♀	Araria
8.	*Oxya velox*	3♀	Bhagalpur, Purba Champaran, Motihari
	Subfamily Hemiacridinae		
9.	*Hieroglyphus banian*	1♀	Jehanabad
10.	*Spathosternum prasiniferum prasiniferum*	7♂, 23♀	Sitamarhi, Nalanda, Bihar Sharif, Muzaffarpur, Darbhanga, Banka, Khagaria, Gaya, Patna, Buxar, Vaishali, Hajipur, Samastipur, Pascim Champara, Bettiah, Supaul, Begusarai, Luckeesarai
	Subfamily Euprepocnemidinae		
11.	*Eyprepocnemis alacris alacris*	2♀	Jamui, Jehanabad
	Subfamily Calliptaminae		
12.	*Acorypha glaucopsis*	6♂, 4♀	Rohtas, Sasaram
	Subfamily Romaleinae		
13.	*Teratodes monticollis*	1♀	Nalanda, Rajgir
	Subfamily Catantopinae		
14.	*Diabolocatantops pinguis*	1♂	Bhagalpur, Gaya, Rohtas, Sasaram, Supaul
15.	*Xenocatantops karnyi*	1♀	Katihar
	Subfamily Cyrtacanthacridinae		
16.	*Schistocerca gregaria gregaria*	2♂, 2♀	Jehanabad, Araria
17.	*Chondacris rosea*	1♂, 2♀	Araria
18.	*Cyrtacanthacris tatarica tatarica*	2♂, 2♀	Araria
	Subfamily Tropidopolinae		
19.	*Tristria pulvinata*	1♂, 8♀	Rohtas, Sasaram, Madhubani, Kishanganj
20.	*Tropidopola longicornis*	1♂	Siwan
	Family Acrididae		
	Subfamily Acridinae		

21.	*Acrida exaltata*	14♂, 19♀	Katihar, Purnia, Saharsa, Muzaffarpur, Siwan, Banka, Pascim Champaran, Bettiah, Supaul, Buxar, Patna, Samastipur, Begusarai, Bhojpur, Ara, Madhepura
22.	*Acrida gigantea*	9♂, 9♀	Siwan, Darbhanga, Nalanda, Rajgir, Saharsa, Gaya, Kaimur, Bhabua, Gopalganj, Muzaffarpur, Rohtas, Sasaram, Katihar, Patna, Begusarai, Saran, Chhapra
23.	*Phlaeoba infumata*	1♂, 1♀	Kaimur, Bhabua, Jamui
24.	*Phlaeoba panteli*	1♀	Munger
	Subfamily Oedipodinae		
25.	*Trilophidia annulata*	2♀	Gaya
26.	*Aiolopus simulatrix*	18♂, 19♀	Kaimur, Bhabua, Gaya, Purnia, Jamui, Munger, Khagaria, Bhojpur, Ara, Saran, Chhapra, Kishanganj
27.	*Aiolopus thalassinus thalassinus*	3♂1♀	Purba Champaran, Motihari, Saran, Chhapra
28.	*Aiolopus thalassinus tumulus*	3♂, 9♀	Jamui, Khagaria, Munger, Rohtas, Sasaram, Bhojpur, Ara
29.	*Chloebora grossa*	1♂, 1♀	Rohtas, Sasaram
30.	*Acrotylus insubricus*	1♀	Sitamarhi
31.	*Oedaleus senegalensis*	1♂, 1♀	Nawada
32.	*Oedipoda miniata miniata*	5♀	Aurangabad, Nawada, Jamui
33.	*Locusta migratoria*	2♂, 4♀	Kaimur, Bhabua, Araria, Purnia
	Subfamily Truxalinae		
34.	*Truxalis nasuta*	1♀	Jamui
	Subfamily Gomphocerinae		
35.	*Chorthippus indus*	1♂	Madhubani
36.	*Leva indica*	1♀	Saharsa
37.	*Leionotacris bolivari*	1♀	Aurangabad

Grasshoppers are annual species having biting chewing type of mouthparts and are of great economic importance, because they constitute an important group of pests and pose a constant threat to cereal, pulses, vegetable crops, orchards, grassland and forest plantations all over the world (Usmani, 2006). Similar work on the collection of grasshoppers and locust fauna from different part of India was reported by Hazra et al. (1993), Reshi et al. (2008), Shishodia and Gupta (2009), Nayeem and Usmani (2012a & b), Akhtar et al. (2012) and Usmani et al. (2012), which provide strengthen to the present findings. Although Bihar is dominating in agriculture and naturally occurring forest, which provides food and balance to the ecosystem, hence, it is a need to control these grasshoppers and locust through environmentally safe methods to increase the yield and balancing ecological processes across the landscapes of Bihar.

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Studies on population dynamics of aphids and their predators on sugarcane at district Shahjahanpur, U.P. India

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Abstract

To study the population dynamics of aphids and their predators, an extensive survey has been conducted in the farmer's field of sugarcane at district Shahjahanpur on monthly basis during 2008-09 and 2009-10. The findings showed that two aphid species *i.e., Sipha flava* and *Ceratovacuna lanigera* were observed to attack on sugarcane; and their predators including ladybird beetles (*C. septempunctata* and *M. sexmaculatus*), lace wing (*Crysoperla carnea*) and hover fly (*Ischiodon scutellaris*) were also found to be associated with aphid colonies. Both aphid and their predators were remained active in the winter (from November to February). The higher infestation of *S. flava* (15.67 % and 230.00 aphids/plant) and *C. lanigera* (16.67 % and 271.33 aphids/plant) was recorded in the month of January. Similarly, predators attained highest population of 18.00 and 16.67 beetles/plant for *C. septempunctata*, 19.33 and 17.33 beetles/plant for *M. sexmaculatus*, 18.00 and 16.67 larvae/plant for *C. carnea* and 15.67 and 14.33 maggot/plant *I. scutellaris* on *S. flava* and *C. lanigera*, respectively. Among different predator species, *C. septempunctata* was recorded most efficient than others and their population also fluctuated in accordance to aphid activity.

1. INTRODUCTION:

Sugarcane belongs to the tall grasses family Poaceae and genus *Saccharum*. There are five recognized species in this genus *viz., Saccharum officinarum*, *Saccharum barberi*, *Saccharum sinensis*, *Saccharum robusstum* and *Saccharum spontaneum*, and the farmers are cultivated first three species more preferably and latter two species are wild ones (Jakson, 2005). *Saccharum officinarum* is a main source of sugar in India and holds a prominent position as a cash crop (Anonymous, 2005). In India, Uttar Pradesh is a major sugarcane producing state, accounting about 79.0 % of sugarcane area of sub tropical region (Singh et al., 2005). Uttar Pradesh itself contributes about 55.6 % of total sugarcane crop in the country. Besides this, other sugarcane growing states are Punjab, Bihar, Maharashtra, Chennai and Andhra Pradesh and their consecutive contribution are 8.9, 8.3, 5.3, 3.3 and 3.1% of total national yield, respectively. In the subtropical regions of India, Uttar Pradesh ranks first with average productivity of about 110.00 tones/ hectare (Anonymous, 2005).

Various factors are responsible for low yield of sugarcane in India *viz.*, extreme hot in summer, excessive rainfall in rainy season, cold and frosty weather in winter. In spite of these factors, the sugarcane crop is also attacked by about 200 species of insect pests at various developmental stages (Cheng et al., 1998). Among them, aphids are most important pest causing heavy losses to the quality as well as quantity of the crop by sucking sap from leaf and stem, and also facilitating secondary infection of virus and fungi. In biosphere, to check the population of aphids, some predators also remain associated with this crop. They are beneficial insects and feed on the nymphs as well as adult of aphids. Considering the importance of aphids on sugarcane, present study has been designed on the population dynamics of aphids and their predators at district Shahjahanpur, Uttar Pradesh, India.

2. MATERIALS AND METHODS:

To collect the aphids and their predators, an extensive survey has been conducted in the farmer's field of sugarcane at district Shahjahanpur on the basis of one month interval during cropping season 2008-09 and 2009-10. A total of one hundred canes (each replicated thrice) have been studied for the experimentation. The sugarcane plants have critically been examined with hand lens for collection of aphids and their predators and specimen (aphid and

predators) collected from the field were subjected for identifications as per suggestions of Nuessly and Hentz (2002), Hentz and Nuessly (2004), Patil and Nerkar (2004) and Patil et al. (2005).

3. RESULTS:

The observations revealed that aphid species collected from sugarcane were identified as sugarcane yellow aphid, *Sipha flava* and sugarcane woolly aphid, *Ceratovacuna lanigera*. However, the predators collected were ladybird beetles (*C. septempunctata* and *M. sexmaculatus*), lace wing (*Crysoperla carnea*) and hover fly (*Ischiodon scutellaris*). The population dynamics showed that both aphid species remained active from the month of November to February on sugarcane at district Shahjahanpur. The higher infestation of *S. flava* (15.67 %) was recorded in the month of January and similar observations were with *C. lanigera* (16.67 %) (Table 1 & 2). On the other hand, aphid (*S. flava* and *C. lanigera*) attained their maximum population of 230.00 aphids/plant and 271.33 aphids/plant in the month of January, respectively (Table 1 & 2).

The data recorded with respected to predators showed that highest population of *C. septempunctata* and *M. sexmaculatus* on *S. flava* and *C. lanigera* were recorded as 18.00 and 16.67 beetles/plant, and 19.33 and 17.33 beetles/plant in the month of January at district Shahjahanpur, respectively (Table 1 & 2). Similarly, the population of *C. carnea* and *I. scutellaris* were recorded maximum of 18.00 and 16.67 larvae/plant and 15.67 and 14.33 maggot/plant on *S. flava* and *C. Lanigera* on infected sugarcane plants, respectively (Table 1 and 2).

Table 1. Population dynamics of sugarcane yellow aphid, *Sipha flava* and their predators on sugarcane at Shahjahanpur

Months	% plant Infestation	Population of *S. flava**	Population of *C. septempunctata**	Population of *M. sexmaculatus**	Population of *C. carnea**	Population of *I. scutellaris**
March	0.00	0.00	0.00	0.00	0.00	0.00
April	0.00	0.00	0.00	0.00	0.00	0.00
May	0.00	0.00	0.00	0.00	0.00	0.00
June	0.00	0.00	0.00	0.00	0.00	0.00
July	0.00	0.00	0.00	0.00	0.00	0.00
August	0.00	0.00	0.00	0.00	0.00	0.00
September	0.00	0.00	0.00	0.00	0.00	0.00
October	0.00	0.00	0.00	0.00	0.00	0.00
November	3.33	56.67	3.67	3.00	2.67	2.67
December	7.33	121.33	8.00	7.00	6.67	6.33
January	15.67	230.00	18.00	16.67	15.33	13.00
February	9.33	97.33	8.67	8.33	7.67	7.00

Data is pooled analysis of cropping year 2008-09 and 2009-10
Sample size = 100 sugarcane plants
***** = Values given in table are plant^{-1}

It was interestingly noticed that among different aphid predators, *C. septempunctata* showed highest potential to feed on both aphid species and it was followed by *M. sexmaculatus*, *C. carnea* and *I. scutellaris* as recorded corresponding minimum values (Table 1 & 2).

4. DISCUSSION:

In the present study, aphids remained active from the month of November to February and highest population of both aphid species was documented in the month of January. The workers of aphids have always recorded its devastating activity in heavy winter on sugarcane and other agriculturally important crops (Nuessly and Hentz, 2002; Hentz and Nuessly, 2004; Patil and Nerkar, 2004; Patil et al., 2005; Ali et al., 2010 and Hadley, 2012). Among different predator species, *C. septempunctata*, *M. sexmaculatus*, *C. carnea* and *I. scutellaris* were also observed to feed on both aphid species and their population also synchronized with the activity of aphids. Similar observations were also recorded by Tripathi (1995), Hodek and Honek (1996), Dixon (1998), Hall (2001), Rabindra et al. (2002), Mote and Galande (2004), Chakravarthy and Gowda (2005) and Easterbrook et al. (2006) and giving further strengthen to the present findings.

Table 2. Population dynamics of sugarcane woolly aphid, *Ceratovacuna lanigera* and their predators on sugarcane at Shahjahanpur

Months	% plant Infestation	Population of *C. lanigera**	Population of *C. septempunctata**	Population of *M. sexmaculatus**	Population of *C. carnea**	Population of *I. scutellaris**
March	0.00	0.00	0.00	0.00	0.00	0.00
April	0.00	0.00	0.00	0.00	0.00	0.00
May	0.00	0.00	0.00	0.00	0.00	0.00
June	0.00	0.00	0.00	0.00	0.00	0.00
July	0.00	0.00	0.00	0.00	0.00	0.00
August	0.00	0.00	0.00	0.00	0.00	0.00
September	0.00	0.00	0.00	0.00	0.00	0.00
October	0.00	0.00	0.00	0.00	0.00	0.00
November	3.67	69.00	4.00	4.00	3.67	3.33
December	7.33	147.00	8.67	8.00	7.67	7.33
January	16.67	271.33	19.33	17.33	15.67	14.33
February	9.67	115.67	10.33	9.67	9.00	8.33

Data is pooled analysis of cropping year 2008-09 and 2009-10
Sample size = 100 sugarcane plants
*** =** Values given in table are plant^{-1}

In conclusion, the findings accomplished that aphids are most vigorous pests of sugarcane and cause serious economic losses in heavy winter (January), and *C. septempunctata* recorded as most active predator followed by *M. sexmaculatus*, *C. carnea* and *I. scutellaris* on aphids, however, their population also fluctuated with inhabitant to aphids.

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Life attributes and morphometrics of cabbage aphid, *Brevicoryne brassicae* Linnaeus (Hemiptera: Aphididae) on cabbage under controlled conditions

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Abstract

Cabbage aphid, *Brevicoryne brassicae* L. is a notorious pest and constantly threatening the production of cole crops especially of cabbage in India. The life attributes along with morphological features of cabbage aphid were investigated under laboratory condition (temperature 26±1°C, RH-70±5% and photoperiod 12 hr L: D). Phenotypically, the body length and width along with cornicle length has been proved to be a useful criterion for separating virginoparous *B. brassicae* instars in samples collected from experimental sites. The observations were recorded on the nymphal period, pre-reproductive period, reproductive period, post reproductive period, adult longevity and fecundity of *B. brassicae*. The average duration of first, second, third and fourth instar was recorded as 1.6±0.48, 1.6±0.66, 2.0±1.09 and 2.9±1.57 days, respectively. The nymph completed total duration within 8.0±1.54 days. In addition, pre-reproductive, reproductive and post-reproductive period were observed as 0.7±0.78, 12.3±3.13 and 2.3±1.1 days, respectively. The average fecundity of female was recorded as 51.0±21.6 nymphs and aphid took 9-19 days to complete their life cycle on cabbage.

1. INTRODUCTION:

Cabbage aphid, *Brevicoryne brassicae* Linnaeus is one of the most vital and notorious pest on variety of the crops including brassica (Rossa et al., 2005; Bonnemaison, 1965). Both adult and nymph suck the cell sap thereby reducing the vitality of plant (Marwat et al., 1985). Apart from sucking the cell sap, they also secrete honeydew which facilitates the growth of sooty mould on the plants (Ali and Rizvi, 2007). In addition, the life cycles of aphids are most remarkable in the winters (Petherbridae and Wright, 1938). They include parthenogenetic and sexual generations, elaborate polyphenisms and obligate shifting between unrelated host plants (Moran, 1992). Earlier studies opined that the difference between species or populations in response to selection by plant features has resulted in morphological specialization for grasping and locomotion (Kennedy, 1986). Since, there exist a number of closely related populations in natural vegetation (Mehrparvar et al., 2012) hence; the morpho-taxonomy can be regarded as a reliable and powerful tool for their identification (Poulios et al., 2007; Mehrparvar et al., 2012). Failing to do so (proper recognition of a pest species) and lack of knowledge pertaining biological features may lead to lower the effectiveness of a management strategy. Therefore, present investigation was aimed to study biological attributes in detail along with phenotypic plasticity of *B. brassicae* on cabbage (*Brassica oleracea* var. *capitata* L.) under controlled conditions.

2. MATERIALS AND METHODS:

To accomplish the objectives, forty days old seedlings of cabbage, *Brassica oleracea* var. *capitata* were transplanted in microplots (sized 3 × 2 m) of experimental field at the Department of Plant Protection, Faculty of Agricultural sciences, Aligarh Muslim University, Aligarh, India in winter season of year 2009. The row to row and plant to plant distance was kept 30 cm each. Irrigation, fertilizers and all agronomical practices were followed at its adequate times. The field exposed for natural infestation of aphids and their attack was observed in the month of December on cabbage plants.

The alate viviparous adult of *Brevicoryne brassicae* were collected from young cabbage plants maintained in the fields of department and brought to the laboratory for further experimentation. Ten adults of *B. brassicae* reared individually on fresh

leaves of cabbage in separate Petri dishes in the BOD incubator calibrated at 26±1°C temperature, 70±5% RH and L: D photoperiod @ 12 hr. The aphid food (cabbage leaves) were changed daily in the morning for entire period of study. The transformation of instar was recorded on the presence of exuviae casted by the nymphs on every moult. In addition, the developmental duration of nymphs, pre-reproductive period, reproductive period, adult longevity and fecundity of *B. brassicae* were recorded till the death of each aphid. The simple binocular microscope was used to differentiate the developmental stages of *B. brassicae* and the body measurements were taken along with the cornicles of aphids.

3. RESULTS:

3.1. Biological attributes of *B. brassicae*:

The biology of *Brevicoryne brassicae* revealed that female showed viviparity and the duration of first, second, third and fourth instar nymphs were recorded as 1.66±0.28, 1.66±0.66, 2.00±1.09 and 2.90±1.57 days in F_1 generation and also as 1.62±0.44, 2.36±0.45, 2.72±0.94, 3.55±0.42 days in F_2 generation (Table 1). Aphid completed nymphal period within 8.00±1.54 and 10.10±1.57 days in F_1 and F_2 generation, respectively. The pre-reproductive, reproductive and post-reproductive period was documented as 0.74±0.15 and 0.93±0.18 days, 12.38±3.13 and 14.55±1.52 days, and 2.30±0.21 and 1.88±0.60 days during F_1 and F_2 generations (Table 1). In addition, adult longevity was recorded as 15.20±2.83 and 17.24±2.27 days in first and second generation. However, the female achieved highest reproductive fecundity of 51.00±3.65 and 38.32±2.33 nymphs in 12.38±3.13 and 14.55±1.52 days during F_1 and F_2 generation, respectively (Table 1).

Table 1. Biological parameters (in days) of *B. brassicae* on cabbage under laboratory condition

	I instar	II instar	III instar	IV Instar	Total nymphal duration	Pre-reproductive period	Reproductive period	Post-Reproductive Period	Adult Longevity	Fecundity Per Female
F_1	1.66±0.28	1.66±0.66	2.00±1.09	2.90±1.57	8.00±1.54	0.74± 0.15	12.38± 3.13	2.30±0.21	15.20±3.83	51.00±3.65
F_2	1.62±0.48	2.36±0.45	2.72±0.94	3.55 ±0.42	10.1±1.57	0.93±0.18	14.55 ±1.52	1.88±0.6	17.24±2.27	38.32±2.33
Range	(1-2)	(1-3)	(1-5)	(1-7)	(8-12)	(0-2)	(9-17)	(1-5)	(9-19)	(26-72)

F_1 = First Generation, F_2 = Second Generation

Table 2. Morphometrical measurements on different developmental stages of *B. brassicae*

S.No.	Stage	Length	Width	Cornicle length
1	I Instar	0.64±0.02 (0.62-0.70)	0.28±0.01 (0.28-0.30)	0.10±0.01 (0.10-0.12)
2	II Instar	0.94±0.06 (0.85-1.05)	0.52±0.04 (0.45-0.60)	0.23±0.02 (0.20-0.75)
3	III Instar	1.43±0.11 (1.17-1.57)	0.69±0.03 (0.65-0.75)	0.37±0.03 (0.30-0.40)
4	IV Instar	1.77±0.07 (1.67-1.90)	0.89±0.06 (0.80-1.00)	0.38±0.04 (0.35-0.05)
5	Adult	1.77±0.08 (1.67-1.90)	0.89±0.06 (0.80-1.00)	0.38±0.04 (0.35-0.45)

Values in parenthesis are range of respective parameters

3.2. Morphometrics of *B. brassicae*:

The observations showed a distinct variation in morphometric measurements on the basis of age of *B. brassicae*. The body length of first instar nymph was found to be ranging from 0.62 to 0.70 mm, and measured an average of 0.64±0.02 mm, while body width varied from 0.28 to 0.30 mm with an average of 0.10±0.001 mm length. The cornicle (sub laterally attached with the abdomen) length was recorded as 0.10±0.001 mm with range of 0.1-0.12 mm (Table 2). When, the nymph enter to second instar stage, it was measured as 0.94±0.06 mm in length and 0.52±0.04 mm with range of 0.85-1.05 and 0.45-0.60 mm, respectively. The length of cornicles was also increased and measured as 0.23±0.02 mm with the range of 0.2-0.75 mm (Table 2). It was interestingly noticed that each nymphal instar was complimentary to each other and the size increased after every molting. The third instar nymph was an average of 1.43±0.11 mm in length and 0.69±0.03 mm in width. The size of cornicle was however gauged 0.37±0.034 mm with range of 0.3-0.4 mm (Table 2). Similarly, the final (fourth) instar nymph attained an average length of 1.77±0.07 mm with range of 1.67-190 mm and width of 0.89±0.06 mm with range of 0.8-1.0 mm. The cornicles were documented as 0.38±0.035 mm long, ranging between 0.35-0.45 mm. It was attention grabbing to note the adults length, width and size of cornicles similar as recorded for the final instar stage of *B. brassicae* (Table 2).

4. DISCUSSION:

4.1. Biological attributes of *B. brassicae*:

Biology of *Brevicoryne brassicae* L., was studied during winter season under laboratory conditions. It was noticed that the species multiplied with viviparous parthenogenetic reproduction throughout the year (Hughes, 1963). With the commencement of viviparity, a distinct variation with respect of time taken to complete a particular life stage was marked among different nymphal stages. Similar duration of immature life was also recorded by Devraj and Singh (2003) and Rossa et al. (2007) in first generation. A relatively prolonged development was however seen in second generation but force deriving the difference could not be identified. There was a marked pre-reproductive period prior to reproduction. The pooled life of *B. brassicae* was also observed to be added by a distinct post reproductive period (Ulusoy and Bayhen, 2006). Debraj and Singh (2003) observed similar duration of the total *B. brassicae* life, while total fecundity revealed proximity with the findings of Najafabadi et al., (2005).

4.2. Morphometrics of *B. brassicae*:

Taxonomists have frequently used phenotypic variations as primary parameters in separating many natural populations of organisms and many species have been described based on the results of these studies (Mehrparvar et al., 2012). Every nymphal instar was complimentary to each other; it was the size only that differentiated them after exuviae (Debaraj and Singh, 2000). The measurements of body length, width and cornicle length of *B. brassicae* nymphs reared under laboratory environment were found to be instar-specific and their size increased with the advancement of age (Hutchison and Hogg, 1983; Singh and Srivastava, 1989). There was generally a little overlap between successive instar and it was evidently easy to separate different nymphal instars accurately on the basis of these measurements (Vaz et al., 2004; Debaraj and Singh, 2000; Gorur, 2004). These phenotypic revelations under present investigation can be used to differentiate inter as well as intra-specific populations of *B. brassicae*.

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Parasitoids of *Artona chorista* Jordan (Lepidoptera: Zygaenidae) from Sikkim: A New Record

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Abstract

Large cardamom is a principal cash crop of Sikkim, India and threatens by the attacked of more than twenty insect pests. Among them, hairy caterpillar, *Artona chorista* is recorded as a major pest of this crop in some areas of Sikkim. Two new hymenoptera parasites *viz., Apanteles* sp. and *Dolichogenidea* sp. were recorded on *A. chorista* for the first time from India. The field parasitism of host larvae was found to be 15.00 and 5.17 percent by *Apanteles* sp. and *Dolichogenidea* sp., respectively.

1. INTRODUCTION:

Large cardamom, *Amomum subulatum* Roxburg (Scitaminae: Zingiberaceae) is a major cash crop of Sikkim, which contributes about 70 % to the total production (3512 tonnes) of India (Subba, 1984). The information on various aspects of this crop was reviewed by Rao et al. (1993). The crop is attacked by more than twenty insect pests, some of which cause serious damage (Table 1). Among them large cardamom foliage feeder caterpillar pests *viz., Cricula trifenestrata* Helfer, 1858 (Lepidoptera: Saturniidae) and *Dasychira inclusa* Walker, 1885 (Lepidoptera: Lymantriidae) was recorded from India for the first time by Yadav and Kumar (2003 & 2004).

In addition, Yadav et al., (1992 & 1993) recorded a new hairy caterpillar namely *Artona chorista* Jordan (Lepidoptera: Zygaenidae) as a major pest of large cardamom in some areas of Sikkim including Assam Linzey, Dikling, Gangtok, Naitham and also from district of Darjeeling, West Bengal *i.e.,* Rango, Suruk, Godak etc. The morphology and symptoms of attack of this pest are closely resembles with *Clelea plumbiola* (Hampson, 1892). The outbreak of *C. plumbiola* was reported during 1978 in some districts of Sikkim and about 80 hectares land was covered with foliar spray of rupees sixty six thousand to check this epidemic (Subba, 1979). Keeping the feeding ability of *A. chorista* on cardamom and also indiscriminate use of chemical insecticides in mind, present study has been made to find out alternative and risk free management strategies through the use of natural parasitoids. The parasites of this species have not been recorded so far. Therefore, present study provides information on the control of *A. chorist*a through natural enemies.

2. MATERIALS AND METHODS:

The leaves of large cardamom infested with larvae of *Artona chorista* were collected from different areas of Sikkim and brought to the laboratory for rearing. The fresh cardamom leaves were provided to the larvae daily till pupation. The study was carried out in the laboratory (13.03±2.9°C temperature and 85.00±8.9 % relative humidity). The parasitoids emerged from *A. chorista* were collected daily. The data were also recorded on sex ratio, longevity and incidence of parasitism of the parasitoid species.

3. RESULTS AND DISCUSSION:

The emerged parasitoids were identified as *Apanteles* sp. and *Dolichogenidea* sp. and they were reported for the first time on *A. chorista* from India.

3.1. Systematic position of parasitoids

Phylum	:	Arthropoda
Class	:	Insecta
Order	:	Hymenoptera
Superfamily	:	Ichneumonoidea
Family	:	Braconidae
Genus	:	*Apanteles* or *Dolichogenidea*

Table 1. Insect pests of large cardamom *Amomum subulatum*

S.No.	Name of insect pest	Order	Family	Reference
1.	*Chrysomela chlorine*	Coleoptera	Chrysomelidae	Azad Thakur 1980
2.	*Basiolepta femoratum*	Coleoptera	Chrysomelidae	Pangtey and Azad Thakur, 1986
3.	Scolytid beetle	Coleoptera	Scolytidae	Azad Thakur, 1982
4.	White grub	Coleoptera	Psocidae	Pangtey and Azad Thakur, 1986
5.	*Pentalonia nigronervosa*	Himptera	Aphididae	Pangtey and Azad Thakur, 1986
6.	*Ropholosiphum padi* Linn.	Himptera	Aphididae	Pangtey and Azad Thakur, 1986
7.	*Ropholosiphum maidis* Fitch	Himptera	Aphididae	Pangtey and Azad Thakur, 1986
8.	*Micrommyzus kalimpongensis*	Himptera	Aphididae	Pangtey and Azad Thakur, 1986
9.	*Pentalonia caladi* Goot	Himptera	Aphididae	Pangtey and Azad Thakur, 1986
10.	*Rhipiphorothrips cruentatus* Cock	Himptera	Jassidae	Pangtey and Azad Thakur, 1986
11.	*Kolla opponens*	Himptera	Jassidae	Pangtey and Azad Thakur, 1986
12.	*Kolla mimica*	Himptera	Jassidae	Pangtey and Azad Thakur, 1986
13.	White grub	Coleoptera	Psocidae	Pangtey and Azad Thakur, 1986
14.	Psocid	Coleoptera	Psocidae	Pangtey and Azad Thakur, 1986
15.	*Glyphepterix* sp.	Lepidoptera	Glyphiperidae	Bhowmick, 1962
16.	*Clelea plumbiola* Hampson	Lepidoptera	Zygaenidae	Subba, 1979
17.	*Eupterote fabia* Crammer	Lepidoptera	Eupterodidae	Subba, 1984
18.	*Bradysia* sp.	Diptera	Sciardae	Kumar and Yadav, 1993
19.	*Artona chorista* Jordan	Lepidoptera	Zygaenidae	Yadav et al., 1993
20.	*Cricula trifenestrata* Helfer	Lepidoptera	Saturniidae	Yadav and Kumar, 2003
21.	*Dasychira inclusa* Walker	Lepidoptera	Lymantiniidae	Yadav and Kumar 2004

3.2. *Apanteles* sp. nov.:

Apanteles sp. ex. *A. chorista* on *A. subulatum*, Collector: Anand Kumar, Gangtok, 1990

3.2.1. Distribution:

India, Sikkim: Assam Linzey, Dikling; West Bengal: Rango Suruk, Godak.

3.2.2. Biology:

Preliminary observations revealed that *Apanteles* sp. is a solitary endo-larval parasite of *A. chorista*. The larvae of parasites came out from the host larva after formation of the cocoon by the host. It then formed a small white silken cocoon beside the dead host larvae. It emerged by making a small hole at one end of the host cocoon. The sex ratio was 1: 1.23 male: female. The unfed males lived on an average 1 day while females survived for 1-2 days. The efficacy of this parasite in field was found to be 15.00 percent. *Apanteles* sp. has been reported as a common parasite of many lepidopteran pests in India (Nair, 1975). Beside present host, biology of *Apanteles* has been reported from the caterpillars of families belonging to Geometridae, Noctuidae, Hesperiidae, Arctiidae, Choreutidae, Saturniidae, Pyraloidea, Tortricoidea, Gelechioidea and Tineoidea (James et al., 2009).

3.2.3. Diagnostic characters:

Forewing with second r-m vein absent, so that the small areolet (second submarginal cell) is open distally; hindwing with vannal lobe distally flattened and with reduced fringe of hairs; punctation of posterior part of mesonotum breaking down into more confluent longitudinal sculpturing, especially submedially; propodeum with oval, pentagonal, hexagonal or anteriorly open medial areola; first metasomal tergite usually with medial subapical depression and second metasomal tergite strongly transverse, often with convex or sinuate posterior margin; ovipositor and sheaths long and exserted, manipulatable via a medially desclerotized hypopygium (subgenital plate). The genus is easily confused or less diverse with *Dolichogenidea*, which differs in having distinct punctures posteriorly on the

mesonotum, and a convex and evenly fringed hind wing vannal lobe.

3.2.4. Synonyms:

= *Cotesia* CAMERON, Men. Manch. Phil Soc, iv, pp: 185 (1891).
= *Microgaster (Apanteles)* THOMSON, Opusc Ent, pp: 2252 (1895).
= *Pseudapanteles* ASHMEAD, Proc Ent Soc Washing, iv, pp: 166 (1897).
= *Protanteles* ASHMEAD, Proc Ent Soc Washing, iv, pp: 166 (1897).
= *Urogaster* ASHMEAD, Proc Ent Soc Washing, iv, pp: 166 (1897).
= *Parapanteles* ASHMEAD, Proc US Nat Mus, xxiii, pp: 131 (1900).
= *Glypatapanteles* ASHMEAD, Proc US Nat Mus, xxviii, pp: 147 (1904).
= *Cryptapanteles* VIERECK, Proc Ent Soc Washing, xi, pp: 209 (1909).
= *Dolichogenidea* VIERECK, Proc US Nat Mus, xi, pp: 173 (1911).
= *Stenopleura* VIERECK, Proc US Nat Mus, xi, pp: 187 (1911).

Genus *Apanteles* was erected by Foerster in 1862 with a type species *Apanteles obscura* Nees. It is one of the most important and well known group of Microgastrinae, forms a genus of enormous extent, containing nearly 600 species. The generic and tribal classification of Microgastrinae has always presented considerable problems, largely because of the size and worldwide distribution of the group and high incidence of morphological convergence and character reduction (Shaw and Huddleston, 1991).

Muesebeck (1920) have placed the majority of microgastrine species in this genus, whether by original designation or by the synonymy. Nixon (1965) recognized the subfamily, formally recognizing the tribe Microgastrinae, which comprised 19 genera. He placed most of the species in *Apanteles*, and divided the genus into 44 species groups for ease of handling.

Mason (1981) established that Nixon's concept of the genus was polyphyletic *i.e.*, not based on a natural grouping, but species in the genus derived from two or more ancestral sources. Mason elevated the tribe Microgastrine to subfamily status, and reorganized the Microgastrinae species into 5 tribes and 51 genera, of which 23 were new. Mason's analysis was rejected by Walker et al. (1990), who showed that *Apanteles sensu* Nixon was polyphyletic, but they did not provided any formal alternative classification for the subfamily, and Mason's classification is currently widely accepted. Austin and Dangerfield (1992) have since revised the Australian Microgastrinae, providing a beautifully illustrated and user-friendly key to this group.

Later on, Whitfield (1997) and Whitfield et al. (2002) have also supported Manson's general approach, but challenge some aspects of his phylogeny and the out group relationships within the lineage of braconid subfamilies related to Microgastrinae and they analyzed further these subfamilies using both morphological and molecular data.

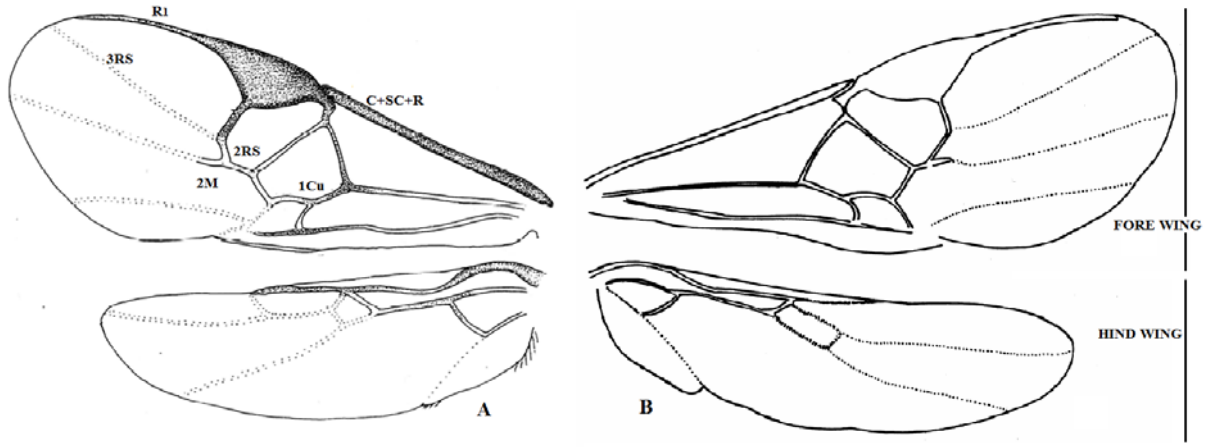
3.3. *Dolichogenidea* Viereck:

Dolichogenidea sp. ex. *A. chorista* on *A. subulatum*, Collector: Sujata Yadav, Assam Linzey, 1990

3.3.1. Distribution:

India, Sikkim: Assam Linzey, Gangtok, Naitham; West Bengal: Rango, Godak.

Fig. 1. Virtual wing venation (fore and hind) of *Apanteles* sp. nov (a) and *Dolichogenidea* Viereck (b)



3.3.2. Biology:

Dolichogenidea sp. is also a solitary endo-larval parasite of *A. chorista*. The nature of parasitism and its emergence is similar to that of *Apanteles* sp. and the sex ratio male: female was 1: 1.73. The average longevity of males was 1 day while females survived for 2-3 days without food. However, field

parasitism was found to be 5.17 per cent. This parasite has also been reported to be attack on the pest of pyraloids, tortricoids, tineoids, gelechioids, Pyralidae, Crambidae, Thyrididae, Mimallonidae, and Elachistidae (Mason, 1981; James et al., 2009).

3.3.3. Diagnostic characters:

Forewing with second r-m vein absent, so that the small areolet is open distally; hindwing with vannal lobe distally convex, bearing an even fringe of hairs; punctation of posterior part of mesonotum remaining distinct submedially; propodeum with oval, pentagonal, hexagonal or occasionally poorly defined medial areola; first metasomal tergite usually broad, with a medial subapical depression and second metasomal tergite strongly transverse, often with a convex or sinuate posterior margin; ovipositor and sheaths long and exserted, manipulatable via a medially desclerotized hypopygium. The genus differs from *Apanteles* in having longitudinal sculpturing posteriorly on the mesonotum, and a flattened and sparsely fringed hindwing vannal lobe.

The genus *Dolichogenidea* was erected by Viereck in 1911 containing about 1000 species. He described *Dolichogenidea* as a subgenus of *Apanteles* because of its elongated genae under which he included *Apanteles* (*Dolichogenidea*) *banksi* Viereck. It resembles with Nixon's *laevigata* group of *Apanteles* except long cheeks. However, Nixon placed *D. banksi* in his *crassicornis* group without observing any specimens. No synonyms have been associated with this taxon yet.

Furthermore, Mason (1981) supported *Dolichogenidea* as ubiquitous genus of tribe Apantelenii under Microgastrinae and also placed *Apanteles* of Nixon under this genus. He also added some new combinations under this genus. Several genera of Microgastrinae are either polyphyletic or at least paraphyletic as currently delineated, and Mason's tribal groupings conflict with recent phylogenetic results (Walker et al., 1990; Mardulyn and Whitfield, 1999). Large scale phylogemetic studies of Microgastrinae based on multiple genes are currently used by many workers (Banks and Whitfield, 2006; Murphy et al., 2008).

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Importance of medicinal plants of Panki Thermal Power Station, Kanpur, Uttar Pradesh: a case study

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Abstract

Present study was confined to the traditional medicinal uses of plants growing in and around the area of Panki Thermal Power Station, Kanpur, Uttar Pradesh. Traditional medicines play a large role in Indian society. The ethno-medicinal study of this campus has been taken to investigate availability and medicinal use of traditional plant maintained in urban environment. A total of 54 species of medicinal plants were collected, out of which 19 species belonging to 15 families have utilized by the inhabitants for their health care. Most of the species were in local distribution and few species were cultivated in gardens. Despite the large urban environment and awareness about modern allopathic medicines, natives of the campus are still using herbal remedies for the treatment of their minor ailments.

1. INTRODUCTION:

Human plant intimate relationship is as old as the origin of human on this planet. With the development of social sense in primitive man, their dependence on the plant resources increased not only for food but also for fodder, fuel, shelter and drug. Utilization of plants for medicinal purposes in India has been documented long back in ancient literature because they are essential to human survival (Shastri and Chaturvedi, 1996). The reference to the curative properties of some herbs in Rig Veda seems to be the earliest records on the use of plants as medicines. Traditional medicines based on herbal remedies have always played a key role in health system of Indian natives. The old traditional Indian system of medicine is one of the most ancient medicinal practices known to the world (Nadkarni, 1908). About 400 plants are used in regular production of Ayurvedic, Siddha, Unani and tribal medicines. Some modern drugs have been deducted from folk lore and traditional medicines. Ethno-botanical plants known for their therapeutic interest exhibit great chemical diversity and several of them have been tested as source of valuable drugs (Shastri and Chaturvedi, 1996). According to Broadbent (2005) urban green area and their associated biodiversity are essential for human right and this diversity provides a wide range of ecosystem services. Despite this importance, very little information exists on the cities flora in general and medicinal species found within its limit in particular. Accelerated pace of globalization and rural urban migration today, people became more prone to diseases, decay and degeneration. Therefore, urban ethno-botany is a rapidly expanding field of study. As people migrate between rural and urban environment, they exchange knowledge on cultural conditions and medicinal plants. So many plants are frequently used by local inhabitants for treatment of various diseases.

Medicinal plants are now in a ‘come back' phase with last two decades and people shifting their focus back to the forgotten traditional natural herbal remedies for cure of their common ailments. Therefore, present paper gives an account on medicinal importance of plant species used by local inhabitants in treatment of various diseases. Although, most of the uses found interesting when present study was compared with published literature on Indian ethno-botany (Jain, 1991; Chopra and Chopra, 1956; Kirtikar and Basu, 1933; Nadkarni, 1908).

2. MATERIALS AND METHODS:

The present study was performed in and around the area of Panki Thermal Power Station, Panki, Kanpur, Uttar Pradesh. The study area is located at 26° north latitude and 80° east longitudes

at the elevation of 126 meters from sea level. Kanpur has continental type of monsoon climate or humid mesothermal climate. The ethno-medicinal study of Panki thermal power campus has been attempted with a view to enlist the common medicinal plant resources and their utilization against herbal remedies.

Field survey has been made in different seasons at various places of thermal power campus *i.e.* wastelands, bare lands, play grounds, road sides, near residential localities and gardens. Collected plants were identified with the help of available literatures (Duthie, 1960; Hooker, 1973). Ethno-medicinal uses of collected plants were then extracted from the relevant literature available (Nadkarni, 1908; Kirtikar and Basu, 1933; Biswas, 1956; Dastur, 1962; Jain, 1991; Arora, 1997; Mehrotra and Mehrotra, 2005). Ethno medicinal uses mentioned in literature were crosschecked through interviews with local inhabitants of this campus.

3. RESULTS AND DISCUSSION:

A total of 54 medicinal plants were collected from the campus of Panki Power House, Kanpur. They were known for their therapeutic value in both organized system of medicine such as Ayurveda, Unani and Homeopathy as well as unorganized system of medicine such as folk medicine. Out of these, only 19 most common plants belonging to 15 families (13 dicots and 2 monocots) were commonly used by these urban natives in caring their health. Most of the species were distributed at local places including home gardens. The data on botanical name, local name, plant parts and their ethno-medicinal are presented in table 1.

Table 1. Systematic account and uses of medicinal plant of Panki Thermal Power Station, Kanpur, U.P., India

S.No.	Botanical name	Local name	Family	Parts used	Ethno medicinal uses
1.	*Aegle marmelos* Corr.	Bel	Rutaceae	Fruit	Pulp used in chronic diarrhoea and dysentery with soothing effects for intestine.
2.	*Allium sativum* L.	Lahsun	Amaryllidaceae	Bulb	Power up immune system, cleans blood, as antibiotic and antifungal.
3.	*Aloe vera* L.	Ghee-kwar	Liliaceae	Leaf gel	Relieve constipation, Rheumatism, Arthiritis, externally used as moisturizer, lowers blood sugar.
4.	*Azadirachta indica* A.Juss	Neem	Meliaceae	Twig Leaf Bark	Used as brush to cure toothache, skin diseases and boils, blood purifier, measles, small pox and wounds, as antiseptic.
5.	*Boerhavia diffusa* L.	Punar - nava	Nyctaginaceae	Roots	Root decoction is given in jaundice, small pieces of roots tied with thread in form of chain are wearied around neck by patients of jaundice. Also as myocardial stimulant and as a diuretic.
6.	*Calotropsis Procera* Br.	Aak/ Madar	Asclepiadaceae		Leaves warmed in oil applied in inflammatory part of the body.
7.	*Crinum latifolium* L.	Sukh darshan	Amaryllidaceae	Leaf	The leaf is warmed and juice is dropped in ear to relieve earache.
8.	*Curcuma longa* L.	Haldi	Zingiberaceae	Rhizome	Mixed with warm milk, it is used in common cold. Juice of fresh rhizomes is used as an antiparasitic and antiseptic for many skin diseases. Externally on indolent ulcers and a paste made from the powered rhizome along with lime forms a remedy for inflamed joints.
9.	*Eclipta alba* Hassk.	Bhangra	Asteraceae	Whole plant	Leaf extract used to head to relieve dandruff and to naturally blacken grey

					hair. Leaf juice boiled with coconut oil used to treat headache and promote hair growth. Plant used in jaundice, urinary infection and liver enlargement.
10.	*Emblica Officinalis* Gaertn	Amla	Euphorbiaceae	Fruits	Useful in liver, piles and stomach ache, rich in vitamin 'C', hence increase resistance in body.
11.	*Eugenia jambolana* Lam	Jamun	Myrtaceae	Seeds	Useful in diabetes, stomach ache, Blisters in mouth.
12.	*Hibiscus rosasinensis* L.	Gurhal/ Java kusum	Malvaceae	Flower	Flower petals boiled in coconut oil applied to head stimulate hair growth.
13.	*Lawsonia alba* L.	Mehndi	Lytraceae	Leaf	Paste of leaves used in headache, burning sensation in feet and hands. Also used as hair conditioner.
14.	*Mentha arvensis* L.	Podina	Lamiaceae	Leaf	Promote digestion and digestive enzymes, sooth stomach ache caused by ingestion, in flatulence.
15.	*Oscimum sanctum* L.	Tulsi	Lamiaceae	Leaf	Decoction of leaves used to cure common colds. Leaf juice useful in bronchitis, applied locally on ringworm and other skin diseases.
16.	*Psidium guajava* L.	Amrud	Myrtaceae	Fruit	Green immature fresh fruit is fried, crushed and mixed with teaspoon of honey. It is used for cough, bronchitis, asthma.
17.	*Ricinus communis* L.	Arandi	Euphorbiaceae	Leaf	Leaves coated with mustard oil and warmed are applied externally over painful joints in rheumatism. Seed oil used as purgative, skin diseases, piles.
18.	*Tinospora cordifolia* (Willd) Miers	Giloya/ Gurich	Menispermaceae	Stem	Stem decoction with sugar is given to cure typhoid. Also used for cold, fever, malaria, ventral complaints and heart problems.
19.	*Trigonella foenumgraecum* L.	Methi	Fabaceae	Seeds/ Leaves	Used for stomach upset, gastrointestinal problems, inflammations, lowering blood sugar, prevents hair fall, for dandruff, soaked and crushed seeds are found to restore hair shaft and promote hair growth. Used as vegetables , beneficial for pain in waist, joints etc.

Various plant parts such as leaves, bark, flowers, fruits, roots, seeds and rhizome of documented medicinal plants were mostly used to cure diarrhea, dysentery, diabetes, bronchitis, jaundice, skin diseases, boils, wounds, ulcers, typhoid, malaria, measeles, small pox, hair growth, respiratory complaints, ear ache, rheumatism etc (Table 1). Many studies have been carried to documented ethno-medicinal information from different parts of the world *i.e.* Tanzania (Augustino and Gillah, 2005), Pakistan (Sardar and Khan, 2009), Ethiopia (Hailemariam et al., 2009), Nepal (Dangol, 2008; Yadav et al., 2011), Malaysia (Lin, 2005), and also support present investigations. However, in India, most of the work has been carried from Kanpur, Uttar Pradesh (Pandey, 1982), tribes of Banda, Uttar Pradesh (Maheshwari and Singh, 1987), Varanasi, Uttar Pradesh (Verma et al., 2007),

Shahjahanpur, Uttar Pradesh (Sharma et al., 2010), Bijnor, Uttar Pradesh (Chaudhary and Kumar, 2011), Andhra Pradesh (Madhu and Yarra, 2011), Kota, Rajasthan (Dadhich et al., 2010), Jaipur, Rajasthan (Pareekh and Trivedi, 2011), Himalayas region (Kumar et al., 2011), Jammu and Kashmir (Mustaq et al., 2011), and also giving further strengthen to the present findings.

A biocultural adaptation was noticed in urban population by Pieroni and Vanderbroek (2007), while they studied past and present contexts between people and plants interaction, and also analyzed trans-national movements in urban living health care. Later on, Tiwari and Pandey (2010) has documented plant species that were used as a traditional cure by rural and urban population of Kanpur, which shows complete corroboration with the present findings. Recently, Aggarwal et al., (2012) identified 76 weed plants belonging to 32 families from different part of Uttar Pradesh, which showing medicinal value for health care. However, Patel (2012) listed 157 medicinal plants placed in 58 families from Bilaspur, Chhatisgarh and also provided their medicinal values for human welfare. Both the findings are support present result to a great extent.

The study finally concluded that despite dense urbanization, medicinal plants still play a key role in human health care. Herbal remedies have become popular in the treatment of minor ailments. Plants commonly used as traditional medicines in rural areas could still be found in the campus of Panki Thermal Power Station, Kanpur, Uttar Pradesh, India. The traditional medicinal practices using native medicinal plants is alive well due to belief in its effectiveness, little side effects, main advantage of being 100% organic and also its cost effectiveness although almost all of them are aware of modern allopathic medicines. It is the knowledge, practice and experiences that have passed on through generations. Therefore, protection and conservation of these important plant species for sustainable use for the future is an immediate need of today.

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Efficacy of chilli mottle virus disease on root constraints of *Capsicum annuum* L. at Agra, India

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Abstract

Chilli (*Capsicum annuum*) is a most important spice of India, which suffers with certain viral diseases, among them chilli mottle virus are most common and cause severe damage by the process of root inhibition, and also prevent the development of new branches. Three year study indicates that root elongation and root initiation in diseased plant retarded highest up to 14.15, 15.85 and 15.00 cm in elongation and 11, 11 and 10 in numbers of root initiation during the month of October during year 2005, 2006 and 2007, respectively. Although, no significant difference in root elongation and root initiation was recorded at germination stage of *Capsicum annuum*, but the difference were noticed with advancement in the age of plant and maximum variation was documented at maturity of crop.

1. INTRODUCTION:

Capsicum annuum L. is the most common and extensively cultivated domesticated species of chilli. Although the species name *annuum* is not represent it as annual plant, though it may also survive for several seasons. It is an important commercial crop grown round the year mainly by small farmers in both rain fed and irrigated area (Hidayat et al., 2012). The crop is always threatened with the infection of different viruses including *Tobacco Etch Virus*, TEV (Shepherd and Purcifull, 1971); Pepper Veinal Mottle Virus, PVMV (Brunt and Kenten, 1971); Pepper Mottle Virus, PMV (Zitter, 1972 and Purufull et. al., 1975) and Chilli Veinal Mottle Virus, ChiVMV (Ong et. al. 1980).

The mottle disease caused by ChiVMV infection was first time reported by Burnett in 1947 from Malaysia (Hidayat et al., 2012), but now a day's, it is well know and widely spread throughout the world specially in Asia including India, Taiwan, Thailand, Indonesia, China, Bangladesh, India, Nepal and Sri Lanka (Hidayat et al., 2012). Viruses usually affect growth of infected plants and also cause up to 30% yield losses to the crops during heavy infection. Although, ChiMV has inhibiting the emergence of new roots and also cause adverse effect on the growth of root (Broadbent and Cooper 1964). Therefore, present study has been made to investigate the effect of chilli mottle virus disease on root constraints of *C. annuum*.

2. MATERIALS AND METHODS:

To accomplish objective, chilli cultivated in the farmer's field at different location of Agra, was review and some pots were also maintained in the Agra College, Agra for the study of infection of virus disease. The infected plants were collected from the field and brought to the laboratory for confirmation of chilli mottle virus disease. After confirmation, the growth of *C. annuum* root were observed on the basis of fifteen days intervals in capsicum fields at Agra and also in the pots kept in green house conditions prevent viral infection. The observations were recorded soon after the showing to maturity of the crop. The time of root infection and length of root and their branches were measured by using scale. Above experiment followed for three consecutive years *i.e.,* 2005, 2006 and 2007.

3. RESULTS AND DISCUSSION:

The data (Table 1) on root initiation and root elongation of healthy and diseased plants were recorded on the basis of fifteen days interval from the month of July to October. The findings revealed no significant difference between healthy and diseased *Capsicum* plants at the time of seed germinations. After few days, the root elongation in the healthy plants was established with more numbers and long branches than diseased ones. The less number of branches with reduced length of root

was observed in diseased plants. The growth reduction in the roots at different developmental stages was influenced with the intensity of the infection of Chilli mottle virus (Broadbant and Cooper, 1964; Brunt et al., 1996; Davis et al., 2002; Hidayat et al., 2012).

Table 1. Effect of chilli mottle virus on root constraints of *Capsicum annuum* at Agra

Observations	Plants	Year 2005		Year 2006		Year 2007	
		Root Initiation	Root Elongations	Root Initiation	Root Elongations	Root Initiation	Root Elongations
15th July	H	6.00±0.173	1.75±0.058	7.00±0.462	1.80±0.116	6.00±0.231	1.80±0.058
	D	4.00±0.404	1.75±0.058	5.00±0.289	1.80±0.058	5.00±0.404	1.80±0.116
30th July	H	9.00±0.462	3.55±0.318	11.00±0.866	3.20±0.173	10.00±0.577	3.35±0.202
	D	6.00±0.231	2.50±0.116	8.00±0.520	2.50±0.145	7.00±0.462	2.50±0.231
15th Aug.	H	14.00±1.039	6.10±0.289	15.00±1.155	6.20±0.231	13.00±0.577	5.90±0.404
	D	9.00±0.577	4.25±0.144	11.00±0.577	4.35±0.202	8.00±0.404	4.25±0.144
30th Aug.	H	19.00±1.155	9.00±0.577	20.00±1.155	8.50±0.404	18.00±0.867	8.00±0.462
	D	12.00±0.577	6.30±0.404	13.00±0.577	5.90±0.346	11.00±0.577	5.75±0.433
15th Sept.	H	26.00±1.155	15.00±0.866	27.00±1.155	14.50±0.866	25.00±1.155	13.00±0.866
	D	15.00±0.577	7.00±0.462	17.00±0.866	6.50±0.289	16.00±0.577	6.25±0.289
30th Sept.	H	30.00±1.155	18.75±1.011	31.00±1.732	19.00±0.866	29.00±1.155	19.50±0.866
	D	19.00±0.866	8.15±0.433	20.00±0.866	7.75±0.433	18.00±0.866	8.50±0.577
15th Oct.	H	32.00±1.443	29.15±1.155	33.00±1.732	26.50±1.443	31.00±1.732	24.00±1.732
	D	21.00±1.155	15.00±0.577	22.00±1.155	10.65±1.155	21.00±1.730	9.00±0.520

H = Observations with respect to healthy plant
D = Observations with respect to diseased plant

The results indicated that highest root elongation of healthy plants of *C. annuum* were recorded as 29.15±1.155, 26.50±1.443 and 24.00±1.732 cm, whereas in diseased plants it was noticed as 15.00±0.577, 10.65±1.155 and 9.00±0.520 cm. in years 2005, 2006 and 2007, respectively (Table 1). Similarly, in diseased plants, the maximum root initiation was observed as 21.00±1.155, 22.00±1.155 and 21.00±1.730 compared to healthy of 32, 33 and 31 during the month of October in year 2005, 2006 and 2007, respectively (Table 1). The finding are well supported with the work of Brunt et al. (1996), Shah et al. (2001), Davis et al. (2002), Taufik et al. (2005) and Hidayat et al. (2012).

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Impact assessment of metacercarians on the air breathing fishes of northern Bihar, India

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Abstract

Maetacercarians are larvae of helminthes and commonly found in the fishes cultivated in oxygen deficient water bodies. These fishes are cultivated via systematic culture and found to be infected with various parasitic diseases. In the present investigations, it was observed that metacercariae and other helminthes stages were associated with various somatic and visceral organs and also causes extensive damage to the fishes. However, symptoms observed were necrosis, fibrosis, and other mechanical damage. The deleterious effects could be assessed from accurate examination of the invaded regions and a clearer picture of pathogenesis of helminthes infection in fishes expected to emerged. The present paper is more fruitful for the producer of air breathing fishes throughout the world.

1. INTRODUCTION:

The famous scientist Malthus said that "food increase in arithmetic ratio, whereas population increase in geometric ratio". This indicates that the food problem will increase in the coming decades. Now a day's, food security is a big problem throughout the word. In addition, fish is considered as proteinous and nutritious food and its increase production can solve food requirement up to a limit (Arastu and Nomani, 2012). Though, many countries are working to search out the importance of fishes for men till date (Verma, 2012). In the water bodies of India, especially at Darbhanga, Bihar, air breathing fishes usually thrive and constitute important fishery resources (Arastu and Nomani, 2012). These fishes may be cultivated in oxygen deficient water by systematic and scientific culture and are subjected to various parasitic diseases. These diseases not only deplete the fish race but also render these diseases to human beings.

In addition, the great stress has been placed recently on the development of air breathing fishes to make a scientific assessment on the role of helminthes as potential pathogen in the north Bihar, India. Therefore, to get a clear image of infections and the effect of the diseases, observations of the infected tissues have been made in the present study.

2. MATERIALS AND METHODS:

Healthy and parasitized air breathing fishes *Clarias batrachus, Channa punctatus* and *Heteropneusts fossilis* were collected from derelict swamps and ponds of district Darbhanga, Bihar. Routine examinations of skin, muscles, gills, viscera and eyes were made through naked eyes, followed by detailed examination of organ concerned in 0.6% saline solution under dissecting microscope.

To segregate the encysted metacercariae associated with muscles, skin, liver, artificial digest were applied by using 0.5% pepsin and 0.5% HCl in 0.65% saline solution. The affected parts were preserved in 10% neutral formalin, Bouin's fluidand Zerker's fixatives for 24-28 hours prior to processing. Paraffin sections were cut (sized 5-7 µ) and stained with haematoxyline and eosin, and subjected to microscopic observations.

3. RESULTS AND DISCUSSION:

The present observations reported the effect of helminthes infections on some vital organs in air breathing fishes including *Clarias batrachus, Channa punctatus* and *Heteropneusts fossilis.* The microscopic examination of skin revealed hemorrhage, hyperemia, patches and necrosis in the superficial areas of body musculature and skin. The tissue elements were merely pushed aside to make room for the strigeoid metacercariae (Fig. 1 and 2). The present findings showed corroboration with experiment of Hoffman (1975) and Bell and Margolis

(1976), they reported that many cercariae penetrate the skin of fish and produce cyst wall, whereas, hemorrhage were also recorded in superficial areas of the body musculature. Later on, Pandey (1971) and Dubey (1980) recorded muscle necrosis in the host tissue around the encysted worm.

Fig. 1. Strigeoid metacercarial cysts scated deep in muscles of *Clarias batrachus*

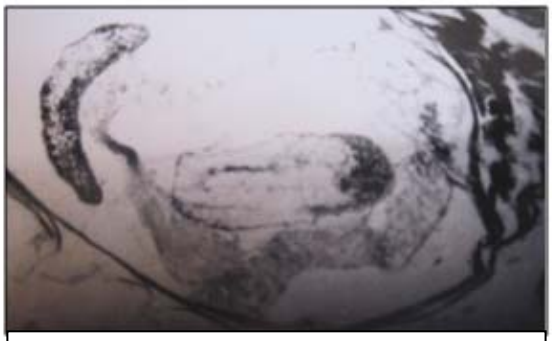

Fig. 2. Photomicrographs of portions of sections of lesioned patches of skin and

Fig. 3. Photomicrographs of portions of parasitized liver of *H. fossilis*

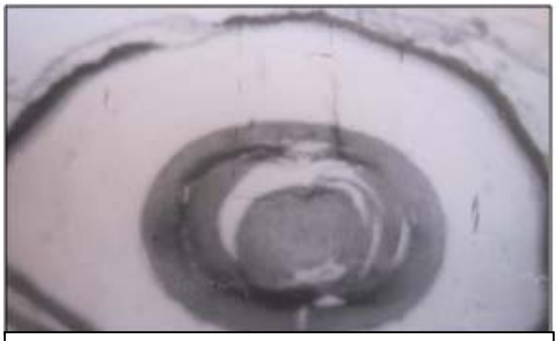

Fig. 4. Section of photomicrographs of the parasitized eye of *H. fossilis*

In infected eyes of fishes, lesion were numerous and varied in their etiology due to variation in the number of metacercarial (Sato et al., 1975; Pandey, 1970; Dubey et al., 1981). Hoffman (1975) reported that the lenses become opaque causing blindness of the diseased fish. Similarly, Cercariae of *Diplostomum* when localize in the eye lens and grow in size, the lens herniation were recorded in the host (Datta Munshi, 1993). However, no such herniation of lens was observed in the present investigations. But observations revealed whitish and opaque eye of infected fishes, photoreceptor cells were disoriented, and parasites were located in the peripheral retina and some retina was displaced from normal position (Fig. 4). Similar observations in the retina of salmon was recorded by Davis et al., (1973) and given further strengthen to present result.

Infected liver contains white dots throughout its surface with pale in colour compare to the bright brown colour of healthy liver of fish. The sinusoids and blood vessels were engorged and hepatic cords lost. The hepatocytes had undergone degeneration (Fig. 3). The liver of teleost does not show diversity of pathology, but susceptible to a number of toxic and metabolic disturbances. The findings are well supported with the work of Dubey (1980), Dubey et al. (1990), Hassan (2005) and Verma (2012), they reported various changes in the liver of the fishes infected with various helminthes parasites.

In the present investigation the strigeoids present in the liver of air breathing fish were not of the cyst forming type, rather they were all actively moving and feeding on the liver tissues. Thus, necrosis, fibrosis and other mechanical damages of the tissues were of much pronounced than those observed by Hoffman (1975) and Sinha et al., (1988), while studied the yellow grub disease of fresh water fish, *Channa punctatus* and also by Chakravaty and Tandon (1989) in *Clarias batrachus*.

The present study provide general information on the impact of metacercariae and other helminthe parasites and also fruitful for the producer of air breathing fishes.

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Short Communication

Haematological observations of fresh water fish *Catla catla* (Ham.) against toxic tannery chemicals

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Abstract

The toxic effect of two tannery chemicals *i.e.,* Basic Chromium Sulphate (BSC) and Nigrosine Black (NB) on the fresh water fish, *Catla catla* were observed at different time intervals (24, 48, 96 hrs and 1 week) with three different concentrations *viz.*, 3, 4 and 5 mg/lit for BCS and 7, 8 and 9 mg/lit for NB. The findings revealed that the clotting time of blood varies significantly from 1.99±1.05 to 3.53±1.10 with BSC and also from 1.99±1.05 to 3.10±1.20 with respect to NB. It was interestingly noticed that the toxicity was increased with increase in the concentration and the time of exposure. Exposure of chemicals disrupts the blood profile and BCS is more toxic than NB.

1. INTRODUCTION:

Fishes were used even at prehistoric ages and they were supposed to be beneficial to long life and intelligence (Daksh and Capoor, 2011). The medicinal value of fish contains fatty acids, essential minerals, salt like calcium, iron, phosphorus, sulphur, magnesium, iodine; vitamins such as vitamin A, B and D. They are low-fat and low-calorie and ideal food for slimming. The researches over the past few decades have shown that the nutrients and minerals in fish, particularly the "Omega-3" polyunsaturated fatty acids, which are heart-friendly and also helps to improve the brain development and reproduction (Verma, 2012).

The natural water is polluted with different pollutants including sewage, industrial waste, tannery effluents etc. Their primary importance is possible hazards to public health and safety of lesser consequence, but still very real destruction of economic value of clean natural waters. Tannery effluents discharged from industries and also from domestic waste are ultimately dumped into sewers or river and known as "storm sewage" (Ingram et al., 1989). The domestic sewage consist of discharges of spent water from wash basins, bathroom and from other sources which is a complex mixture of mineral and organic matter. The treatment of polluted water is necessary prior to human use for various practices. The aim of present study is to check out the sublethal effect of tannery chemicals on haematological parameters of fresh water fish *Catla catla*.

2. MATERIALS AND METHODS:

The fishes were collected from the Government fish farm Laramada village, river Yamuna at Agra and also purchased from local market of district Agra, acclimated in the laboratory. Furthermore, they were exposed in sublethal concentrations of Basic Chromium Sulphate (BCS) @ 3, 4, 5 mg/lit and Nigrosine Black (NB) @ 7, 8, 9 mg/lit for the period of 24, 48, 96 hrs and 1 week. On the other hand, a control was run simultaneously, for which no chemical injected in the body of fishes. The culture of infected and uninfected fishes was maintained in the aquarium (APHA, 1992).

The clotting time was observed through Duke's method as described by Wintrobe et al. (1968). The duration of time required for the blood to clot at normal room temperature (37±1°C) were recognized as clotting time. A drop of freshly drawn blood was taken from the fishes and placed on a clean and dry slide and also calculate the clotting time. Repeatedly, a clean needle was slowly passed through the drop of blood at regular interval till a fibrin thread could be pulled out by the point of the needle, this was an indication that clotting has started and time was noted by stopping the watch. The clotting time was recorded in unit of minutes.

3. RESULTS AND DISCUSSION:

When the fishes, *Catla catla* exposed for tannery chemicals (BCS @ 3, 4, 5 mg/l and for NB @ 7, 8, 9 ml/l), the clotting time was varied significantly from 2.33±0.89 to 3.53±1.10 min with respect to exposure period (varied from 24 to 1 week). However, control showed a variation of 1.99±1.05 to 2.34±1.45 (Table 1). These finding are well supported with the work of Agarwal (1994), who reported increased blood clotting time in *Heteropneustes fossilis* (Bloch) against the exposure of zinc. However, Nath and Jaipuryar (1996) recorded no significant change in the clotting time with the toxicity of lindane in *Heteropneustes fossilis* (Bloch).

Table 1. Clotting time in *Catla catla* after exposure of BCS and NB toxicants

S.No.	Conc.	Control (Mean±SD)	24 hrs (Mean±SD)	48 hrs (Mean±SD)	96 hrs (Mean±SD)	1 week (Mean±SD)
A. Basic Chromium Sulphate (BSC)						
1.	3 mg/l	1.99±1.05	3.01±1.99**	3.23±1.99**	3.33±1.55***	3.39±1.12**
2.	4 mg/l	2.34±1.45	3.12±2.01**	3.22±1.78**	3.45±1.01****	3.51±1.39**
3.	5 mg/l	2.34±1.11	3.16±1.76**	3.29±1.10***	3.47±0.99****	3.53±1.10***
B. Nigrosine Black (NB)						
1.	7 mg/l	1.99±1.05	2.33±0.89*	2.46±0.98**	2.94±0.49***	2.94±0.72***
2.	8 mg/l	2.34±1.45	2.45±1.10*	2.49±0.98**	2.89±1.02****	2.92±0.45***
3.	9 mg/l	2.34±1.11	2.99±0.88**	3.00±0.68**	3.09±1.10****	3.10±1.20****

* Non-significant (P>0.05) ** Significant (P<0.05)
*** Highly significant (P<0.01) **** Very highly significant (P<0.001)

It was interestingly noticed that the toxicity was increased with concentrations and exposure time. The supported findings are John (2006), investigated increased clotting time in *Mystus vittatus* against the exposure of metasystox and sevin. The observations revealed that exposure of chemicals disrupt the blood profile and BCS are more toxic than NB. Recently, Seikh et al. (2009) made observations on toxicity of leather dyes on blood parameters of *Cirrhinus mrigala* and showed complete corroboration with present outcome.

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Short Communication

Management and conservation of Blackbuck, *Antilope cervicapra* population at Sikandra in district AGRA, U.P., India

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Abstract

The *Antilope's* dwindling numbers in protected as well as wild populations resulted in its inclusion in Schedule 1 of Wildlife (Protection) Act, 1972. The population residing at Sikandra, Agra (U.P.) has fluctuated and reduced over the decades. The associated reasons were identified and a conservation and management plan was drawn which is essential for sustainability of healthy population of Blackbuck.

1. INTRODUCTION:

The *Antilope* was once found in large number all over the Indian subcontinent. Nowadays, their number decimated as they were largely hunted for their meat and sport. Although, Ranjitsinh (1989) was estimated their population between 22,000 and 24,000, which was reduced largely as compared to 80,000 estimated in the sixties. Even now they are more commonly found outside protected areas (Brander, 1923; Rahmani, 1991). The diminishing numbers of this animal resulted in its placement in the Part 1, Schedule 1 of Wildlife (Protection) Act 1972.

A small population of blackbuck flourishes in the semi-wild habitat of Sikandra, tomb of Emperor Akbar at Agra. Blackbucks reside in the lawns and adjoining area of tomb and are also matter of anthropogenic pressure (Saluja et al., 2012). There were little works has done to maintain their stable healthy population in this monument (Rahmani, 1991). But after two decades, some measures need to be implemented strictly for a sustainable existence of this species. Therefore, present study provides information on conservation and management of blackbuck, *Antilope cervicapra* at Sikandra, Agra.

2. MATERIALS AND METHODS:

The field visits were made to record actual number of blackbuck and they were directly counted at an instance. For this purpose 7 X 50 'Nikon' binoculars were used to trace the distant animals; particularly for fawns and juveniles, which were difficult to locate with naked eyes. The process was followed throughout the year, and suggestions in relation to the reason on decline in the numbers of this population could be drown.

3. RESULTS AND DISCUSSION:

3.1. Management of feeding grounds: Blackbuck at Sikandra relied entirely on grasses, which are available in only 25 % of total field area. These grasses were inadequate in providing proper nutrition to a substantial population of blackbuck. However, deterioration in health of animals was clearly visible during summer. Therefore, the grasses should be thoroughly watered in order to provide constant supply of food to antelopes throughout the year. It is confirmed by Jhala (1997), who evaluated seasonal effects on nutritional ecology of blackbuck.

3.2. Provision of supplementary food: During summers, when the grasses dry up, a substantial population can be maintained well by providing supplementary food at fixed hours. This supplementary food could include those items which they are reported to feed upon in the wild and in those habitats where they rely on agricultural crops, for example gram (Ranjitsinh, 1989) and rice, mas dal, wheat and mustard (Lehmkuhl, 1980). This could help the animals in sustaining themselves when grasses are unable to support their dietary requirements.

3.3. Need for experts: During present study, wounded males were noted but no medical assistance was made available to them. Therefore, wildlife experts and veterinary doctors should also be appointed for surveying the health of animals at regular intervals.

3.4. Reducing anthropogenic pressures through wildlife guards: Sikandra is a tourist spot and rush of visitors is quite obvious at this place in Agra. We observed that sometimes people entered in the lawns and unnecessarily frightened this innocent animal. On occasion (picnic), a group of about 30 students chased the animals from the lawns to the forest.

Local interview of some workers of the monument established that animals also succumbed to the effect of shock. This was probably due to human disturbances, which made the animals awestruck. So, wildlife guard should be kept to strictly stop the visitors from getting into the lawns. These guards could also help in checking illegal hunting. *Antilope cervicapra* is very shy and avoid the presence of human beings. Therefore, only workers should be allowed to move quietly through the lawns.

3.5. Need of scientific studies: Studies should also be made on the population of antelopes at regular intervals which covers every aspect of their behaviour. A population census should also be carried out at regular intervals so that a record could be maintained regarding any fluctuation in the number of animals.

3.6. The authorities should make efforts in detecting the casualties: During present observation, it was noticed that few carcasses of antelopes are also available at Sikandra, Agra. The authorities, who are taking care, should be scheduled to investigate the associated reasons for their mortality. It appeared that there was no caretaker of these animals because one carcass lay there for about fifteen days.

4. ACKNOWLEDGEMENTS:

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